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THE INHERITANCE OF PATHOGENICITY IN COCHLIOBOLUS CARBONUM

R. R. Nelson and A. J. Ullstrup

Pathologists, Crops Research Division, ARS, U.S.D.A., Raleigh, North Carolina and Lafayette, Indiana.
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SUMMARY

Studies on the segregation of ascospore isolates of *Cochliobolus carbonum* indicate that pathogenicity is controlled by a single gene inherited independently of the gene for compatibility. Of 400 isolates from crosses of race 1 × race 2, 203 were race 1 and 197 were race 2. All isolates from crosses of race 1 × race 1 and race 2 × race 2 were respectively race 1 and race 2. Ascospore progenies from all crosses segregated 1:1 for compatibility. Both races are found in both compatibility groups in nature, but nearly all wild-type isolates in compatibility group A are race 1 and nearly all in group a are race 2. Since resistance in the host and pathogenicity in the parasite are both controlled by a single gene, the disease might be suitable for studies on the nature of resistance and pathogenicity.

Helminthosporium carbonum Ullstrup was described (3) in 1944 as causing a leaf disease and ear infection of corn. Ullstrup demonstrated that only a few inbred lines were susceptible to the disease and that the species comprises 2 races, designated races 1 and 2. The races are identical in morphology and in symptoms incited on ears, but are easily differentiated by leaf symptoms produced on selected inbred lines. On inbred Pr, as well as on certain other inbreds and single crosses composed of susceptible inbreds, race 1 isolates produce well-defined zonate lesions with light-brown centers and darker-brown margins, and race 2 isolates produce only chlorotic-necrotic flecks (Fig. 1).

Cochliobolus carbonum Nelson, the perfect stage of *H. carbonum*, was obtained recently in paired cultures of conidial isolates (1). Subsequent studies demonstrated that compatibiltiy, or mating type, is controlled by a single major gene locus (2). Research on the inheritance of factors for pathogenicity is reported herein.

Materials and methods.—Nine conidial and 13 monoascoporic isolates were used in 15 different crosses to obtain ascospores. Five of the crosses were made between conidial isolates, 7 between ascospore isolates, and 3 between an ascospore isolate and a conidial isolate. The techniques have been described (1). Each ascospore isolate was mated to both parental strains and to selected tester lines to determine its mating reaction.

A medium of 200 ml of Campbell's V-8 juice, 3 g of $CaCO_3$, 20 g agar, and water to make 1000 ml was used to increase isolates for inoculation studies. Spore suspensions of each isolate were prepared with cultures 7–10 days old. Since differences in host reaction to races 1 and 2 of the pathogen are qualitative, no effort was made to standardize spore loads among isolates. One susceptible and 5 resistant inbreds or 1 susceptible and 1 resistant single cross were used to determine race reaction of each isolate. Seedlings in the 3- or 4-leaf stage were inoculated with spore suspensions by spraying with a de Vilbiss No. 15 atomizer. Seedlings were kept at 24°C in a moist chamber for 16 hours after inoculation and then transferred to a greenhouse at 24–30°C.

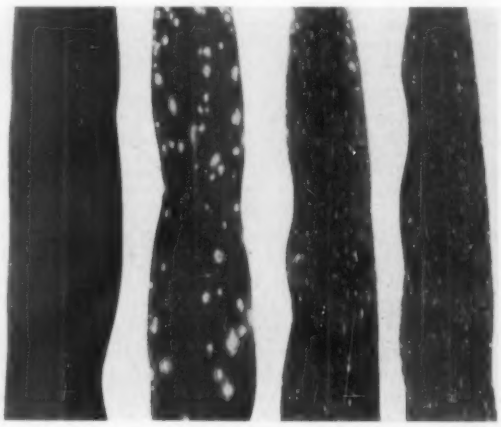

Fig. 1.—Left to right: Healthy seedling leaf; susceptible reaction to race 1 of *H. carbonum*; resistant reaction to race 1; and reaction to inoculation by race 2. The last 2 are indistinguishable.

Results.—Monoascosporic isolates from 18 different crosses were studied for race reactions and mating types. The number of isolates obtained from any single cross ranged from 24 to 98. Of the total of 973 isolates, 400 were from 8 crosses of race 1 × race 2, 305 from 5 crosses of race 1 × race 1, and 268 from 5 crosses of race 2 × race 2.

Of the 400 monoascosporic isolates from crosses of race 1 × race 2, 203 were race 1 and 197 were race 2 (Table 1). All isolates from crosses of race 1 × race 1 and race 2 × race 2 were respectively race 1 and race 2. No isolate demonstrated a degree of virulence intermediate between race 1 and race 2.

Pathogenicity and compatibility are inherited independently (Table 1). Ascospore progenies from crosses of race 1 × race 2 segregated about 1:1 for compatibility (A and a) and pathogenicity (race 1 and race 2). Progenies from crosses of race 1 × race 1 and race 2 × race 2 also segregated about 1:1 for

Table 1.—Segregation for pathogenicity and compatibility in progenies of *Cochliobolus carbonum*.

Cross	No. spores isolated	Compatibility and race reaction of ascospore isolates			
		A		a	
		Race 1	Race 2	Race 1	Race 2
Race 1 × Race 2					
1	46	8	11	14	13
2	35	11	9	7	8
3	27	8	9	4	6
4	26	9	6	6	5
5	74	26	19	13	16
6	62	16	12	18	16
7	45	7	10	13	15
8	85	22	24	21	18
Race 1 × Race 1					
1	54	25	0	29	0
2	45	20	0	25	0
3	98	51	0	47	0
4	62	37	0	25	0
5	46	22	0	24	0
Race 2 × Race 2					
1	32	0	18	0	14
2	24	0	11	0	13
3	82	0	36	0	46
4	47	0	22	0	25
5	83	0	40	0	43
Totals:					
Race 1 × Race 2	400	107	100	96	97
Race 1 × Race 1	305	155	0	150	0
Race 2 × Race 2	268	0	127	0	141
	973				

compatibility. Segregation for pathogenicity and compatibility was computed for 39 ascus progenies, including 11 eight-spored asci. The expected 1:1 segregation for pathogenicity and compatibility occurred in all eight-spored asci, whereas all combinations less than 1:1 occurred in asci containing fewer than 8 spores.

Discussion.—The results strongly indicate that pathogenicity in *C. carbonum* is controlled by a single gene. Both of the key differentials of corn used, inbred Pr and single cross Pr × K61, are susceptible to race 1 and resistant to race 2. Unfortunately, there are no lines of corn that, based on leaf symptoms, are susceptible to race 2 and resistant to race 1, thus precluding reciprocal testing. Because of the limited number of differential lines available, the possibility cannot be eliminated that one or more additional genes are involved in pathogenicity. Even so, the fact that none of the ascospore isolates was intermediate in virulence between the 2 races or exceeded the virulence of race 1 is supporting evidence for a single gene for pathogenicity.

Analysis of ascospore segregations demonstrates that the factors for pathogenicity and compatibility are inherited independently. Both races are present within the 2 compatibility groups in nature, but not in equal numbers. Twenty-one conidial isolates from naturally infected leaves and ears of corn from diverse geographic areas have been tested for compatibility in these and previous studies. Nine belong to compatibility group A, 7 to group a, and 5 remain unclassified, apparently because of genetic complexities in the sexual mechanism. Eight of the 9 A isolates are race 1, and 5 of the 7 a isolates are race 2. It is probable that race 2 originated as a mutation of race 1, because race 2 is markedly less virulent and less specialized, but the alternative possibility cannot be eliminated. The presence and prevalence of the 2 races in the compatibility groups could be accounted for by subsequent similar mutations or through genetic recombination. The sexual stage is unknown in nature. The limited occurrence of the disease has restricted the number of isolates collected, but both compatibility types have not been isolated from the same plant or even from the same field.

From a purely applied viewpoint, the significance of this disease is little more than academic, particularly in view of the fact that resistance is conferred by a single dominant gene, (4). A single gene for resistance in the host and a single gene for pathogenicity in the parasite suggests, however, that this disease would afford an ideal tool for studying the basis of resistance and pathogenicity.—Department of Plant Pathology, North Carolina State College, Raleigh; and Department of Botany and Plant Pathology, Purdue University, Lafayette, Indiana.

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FACTORS INFLUENCING STORAGE DECAY OF SUGAR BEETS BY PHOMA BETAE AND OTHER FUNGI

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SUMMARY

Phoma betae predominated among isolates from diseased sugar beet roots in southern Alberta. In inoculation tests, *P. betae* and *Pythium* spp. caused more damage to stored roots than *Fusarium* spp., *Aphanomyces cochlioides*, and *Rhizoctonia solani*. Individual roots varied greatly in susceptibility to decay. Decay increased with rise in temperature from 10 to 25°C with all fungi studied except *Fusarium avenaceum*, which was most virulent at 20°C. Root sections wilted for 24 hours before inoculation were markedly predisposed to decay by *P. betae* at 15, 20, and 25°C. At 5 and 10°C there was little difference between decay in the wilted and unwilted sections. Relatively dry storage conditions favored decay by *P. betae* and retarded decay by *Pythium ultimum*.

Introduction.—In southern Alberta, root decay of sugar beets by parasitic fungi is seldom important when conditions are favorable for harvesting and storage. Considerable damage can occur, however, under adverse conditions. For example, of over 5000 beet roots examined during removal from storage piles in November, 1949, 5.4% were infected and 1.9% were severely rotted (1). Most of the damage apparently occurred before or during the prolonged wet harvest period, since root decay was moderate to severe in nearly one-third of the fields examined. Examination of beets stored in the piles for varying periods indicated little or no progress or spread of the decay during storage.

Observations in southern Alberta confirmed reports from Colorado (2, 3) and the U.S.S.R. (6) that decay by fungi increased greatly when beets were allowed to wilt before storage. Decay was also obviously influenced by temperature and moisture. Tompkins and Pack (7) found that rotting of sugar beets by *Phoma betae* Frank increased with rise in temperature from 1 to 15°C. Fairly high temperatures often prevail in the field during harvest and at the beginning of the storage period in southern Alberta, and moisture conditions are extremely variable. Experiments were conducted under controlled conditions at Lethbridge because further study was required on the factors affecting decay of sugar beets by *P. betae* and other root pathogens prevalent in that area.

Materials and methods.—Mature roots of the Alberta No. 8 strain of sugar beets were stored in a covered pile at 5°C until required. Before inoculation the roots were trimmed, washed, and dipped in a 1% Lysol solution to reduce surface contamination. They were cut longitudinally into 4 or more equal sections, each weighing not less than 100 g. Preliminary tests showed that beets differed greatly in susceptibility to decay, so treatments were applied to sections from an individual root to minimize variation between units. Fifteen to 20 roots were used for replication in each experiment.

Inoculations were made with 5-mm discs from cultures of the fungi grown for about 10 days on potato-dextrose agar in Petri dishes. The inoculum was inserted in a hole ¼ in. deep and ¼ in. in diameter made with a cork borer in the outer uncut portion of the root section. For the controls, a disc of sterile agar was placed in the hole. The core of tissue removed was replaced after inoculation. On the basis of preliminary experiments, inoculation was midway between the crown and tip of the root.

To determine the effect of wilting on decay, root sections were exposed at room temperature before inoculation. Sections exposed for 24 hours were more susceptible to decay than those exposed for 12, 36, or 48 hours, and the degree of infection was comparable to that in whole wilted roots.

In most experiments the inoculated root sections and controls were stored in controlled-temperature rooms in vermiculite with moisture content adjusted on an oven-dry basis. They were buried in this medium in single layers in wooden flats covered with wax paper. After incubation for 2 weeks under the required conditions, the decayed portion of each section was carefully cut out and weighed. Initial and final weights of the root sections were also recorded to determine moisture losses during wilting and incubation.

Results.—*Screening tests with fungi.*—*Phoma betae* predominated among the isolates from diseased roots of sugar beets in southern Alberta, but several other fungi were also associated with the damage. The relative importance of these fungi as agents of root decay was determined in a series of inoculation tests at 20°C. The number of isolates tested and the range in virulence in each group were: 30 *Phoma betae*, slight to severe; 19 *Pythium* spp., slight to severe; 12 *Fusarium* spp., nil to moderate; 10 *Aphanomyces cochlioides* Drechs., trace to slight; 14 *Rhizoctonia solani* Kühn, trace to slight.

Isolates of *P. betae* differed in virulence, but most of them caused more decay than any of the other fungi studied. *Pythium* spp. (mainly *P. ultimum* Trow) varied greatly in virulence, but generally caused less damage than *P. betae*. Decay by *Pythium* spp. was usually lighter in color and more watery than decay caused by *P. betae*. *Fusarium avenaceum* (Fr.) Sacc. and *F. oxysporum* Schlecht emend. Snyd. & Hans. did not occur commonly but caused a slight to moderate decay indistinguishable from that produced by

P. betae. The other fungi isolated produced only superficial lesions. No decay developed in the control treatments except for occasional contaminations.

Influence of temperature and wilting on decay.—In a series of inoculation tests, *Phoma betae*, *Pythium* spp., *Fusarium* spp. (exclusive of *F. avenaceum*), *Aphanomyces cochlioides*, and *Rhizoctonia solani* caused increasing decay with rise in temperature from 10 to 25°C. *F. avenaceum* proved most virulent at 20°C.

Studies were made on the effect of temperature on infection of wilted and unwilted root sections by *P. betae*. Sections inoculated immediately after cutting and after exposure for 24 hours were incubated at 5, 10, 15, 20, and 25°C in vermiculite containing 25% moisture. Losses in weight during the wilting period averaged 13.2% (Table 1). During incubation the wilted sections absorbed some moisture at 5, 10, and 15°C, but at 20 and 25°C lost weight, through increased evaporation.

As shown in Table 1, decay was much greater in the wilted sections than in the unwilted ones at 15, 20, and 25°C, but the differences were slight at 5 and 10°C. Decay developed slowly at all temperatures in the unwilted sections. Results were similar in experiments with *Pythium ultimum*.

Table 1.—Effect of temperature on decay of wilted and unwilted sections of sugar beet roots inoculated with *Phoma betae* and on weight losses in wilted sections.

°C	Av. weight (g) of decayed portion[a]		% loss in weight of wilted sections[b]	
	Wilted	Unwilted	Before inoculation	During incubation
5	1.4	0.8	12.6	10.9
10	2.9	2.1	12.7	10.7
15	8.9	2.3	12.7	11.3
20	16.5	2.4	13.4	15.3
25	20.2	2.9	14.7	17.8

[a] LSD at 1% level, 3.7.
[b] Based on original weight.

Influence of moisture on decay.—Preliminary studies indicated that relatively dry storage conditions favored root decay caused by *Phoma betae* and retarded that caused by *Pythium* spp. For example, when root sections were inoculated with these fungi and incubated at 20°C in vermiculite that was relatively dry (20% moisture) and relatively wet (40% moisture), the respective average weights of the decayed portions were: *Phoma betae*, 15.4 and 1.6 g, and *Pythium ultimum*, 3.9 and 8.4 g.

The differential effect of moisture on decay by these two fungi was studied further in an experiment with wilted and unwilted sections of roots. For each pathogen, one section of each root was dried at room temperature for 24 hours, inoculated, and incubated in vermiculite containing 25% moisture. Unwilted sections of each root were inoculated and incubated in vermiculite at moisture contents of 25, 35, and 47%, which moistures remained reasonably constant during 2 weeks at 20°C.

Table 2.—Influence of storage moisture at 20°C on decay of wilted and unwilted sugar beet root sections inoculated with *Phoma betae* and *Pythium ultimum*.

Pathogen	Av. weight (g) of decayed portions[a]			
	Wilted sections at 25% moisture	Unwilted sections at		
		25%	35%	47%
Phoma betae	11.6	5.2	3.1	1.9
Pythium ultimum	7.7	1.6	2.4	3.2

[a] LSD at 1% level, 2.2.

The average weights of the decayed portions are given in Table 2. As in previous experiments, both fungi caused significantly more decay in wilted than in unwilted sections under the same storage conditions. In the unwilted sections, decay by *P. betae* was significantly higher at 25% than at 47% moisture, whereas *Pythium ultimum* tended to cause increased decay at the higher moistures.

Sugar beet roots differed greatly in inherent susceptibility to decay by *P. betae*. Wilting and moisture treatments that favored decay by *P. betae* did not affect the relative resistance of the roots. Roots that were resistant to decay by *P. betae* were also resistant to *P. ultimum*.

Discussion.—The results affirm the need, emphasized by Gaskill (2, 3), for prompt removal of harvested sugar beets from the field. Prevention of wilting appears to be particularly important during warm weather since decay of wilted root sections by *Phoma betae* was greatly accelerated at temperatures above 10°C.

Decay by *P. betae* was relatively slight in both wilted and unwilted root sections stored at 5 and 10°C. This may explain the apparent lack of spread of root infection in sugar beet storage piles in southern Alberta (1). If low temperatures prevail after the roots are placed in these piles, most of the fungi predominant in that area are not likely to cause further decay. This may not apply to other areas and other fungi; however, since Gaskill and Seliskar (5) reported that the rate of rotting by *Botrytis cinerea* Fr. in Colorado did not vary greatly over the temperature range 40–83°F.

When storage decay of sugar beets is a problem, control is difficult because of the many factors involved. In addition to the influence of moisture and temperature on decay, there are marked differences in the response of the pathogens and host. Isolates of *P. betae* and other fungi differ markedly in virulence; and, in addition, individual roots and strains of sugar beets vary greatly in susceptibility to decay (4). In the present study, roots resistant to decay by *P. betae* were also resistant to *Pythium ultimum*. Gaskill (4), however, showed that resistance to *P. betae* was apparently independent of resistance to *Botrytis cinerea*.

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EFFECT OF TEMPERATURE ON THE MULTIPLICATION OF POTATO VIRUS X IN THE PRESENCE AND ABSENCE OF POTATO VIRUS Y

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SUMMARY

Turkish tobacco plants inoculated with potato virus X (PVX) or with a mixture of PVX and potato virus Y (PVY) and placed in constant-temperature chambers at 19°, 28°, or 32°C were assayed at intervals for PVX activity by inoculations to *Gomphrena globosa*. Only those leaves systemically invaded during rapid expansion were assayed. In both singly and doubly infected plants, an increase in temperature (within the range studied) increased the rate of PVX multiplication during its rapid phase, decreased the duration of the rapid phase of PVX multiplication, and decreased the total amount of PVX synthesized or accumulated. The PVX-PVY interaction, as measured by the amount of PVX formed as a consequence of PVY infection, varied with the temperature: the absolute increase in PVX due to PVY infection was about twice as great at 19° as at 32°. The ratio of PVX in doubly infected leaves (X_{xy}) to that in singly infected ones (X_x) varied from about 2.2 at 19° to 11.5 at 32°; most of this variation resulted from the marked influence of temperature on X_x. When different day and night temperatures were used, neither the PVX concentration nor the X_{xy}/X_x ratio exceeded the limits characteristic of tests in which the two temperatures used were held constant. High temperature had no permanent limiting effect on PVX synthesis, for PVX synthesis resumed in plants placed at 24° after being held at 32° until PVX accumulation had virtually stopped.

In mixed infections by unrelated viruses, one virus sometimes stimulates the multiplication of another (2, 4, 5, 7, 8, 11, 19, 20). Potato virus X (PVX) appears to be unusually sensitive to the presence of other viruses; the nature and extent of the interaction is dependent on the identity of the other virus in the plant (7, 8), the strain of PVX used (7, 9), the sequence of inoculation (7, 9, 19, 20), and the stage of infection—local, acute, or chronic (7, 9). The interaction between PVX and potato virus Y (PVY) is not affected appreciably by host nutrition or the strain of PVY (7, 9).

Previous studies (7, 9, 12, 13) on the interaction between PVX and PVY have led to several hypotheses on the possible nature of the mechanism by which infection by one virus stimulates synthesis of another. Before these hypotheses can be tested, it is necessary to determine the factors affecting the extent of such stimulation so that results can be reproducible. That the variables mentioned above are not the only ones affecting the interaction is evidenced by the inconsistency in results reported from different laboratories (1, 3, 9, 10, 15). Rochow and Ross (9) noted a seasonal variation in the extent of the interaction, which was strongest in the spring and fall, and suggested that temperature may be an important aspect of this phenomenon. Although no information is available on the quantitative effect of temperature on the multiplication of PVX in plants also infected by PVY, there are a few reports on the effect of temperature on the multiplication of the two viruses in single infections. Our data indicate that the concentration of PVY about 2 weeks after inoculation is greater at 27° than at 21° (9) and about the same at 28° as at 32° (16). Pound and Helms (6) investigated PVX accumulation at 16°, 20°, 24°, and 28°C and found lower concentrations of infectious virus in plants held at 16° or 28° than in plants maintained at either 20° or 24°. In general, virus accumulation was greatest at about 20° and decreased progressively as higher temperatures were used, although the optimum temperature appeared to vary with the seasons.

The present investigation was conducted to determine the extent to which the PVX-PVY interaction is affected by temperature. These studies involved a comparison of PVX multiplication in singly and doubly infected plants kept at various temperatures following inoculation. A preliminary report has been published (17).

Materials and methods.—The virus strains used were the same as those described by Rochow and Ross (9). In Turkish tobacco (*Nicotiana tabacum* L.) the PVX strain induces no obvious symptoms or sometimes

a very mild systemic mottle with an occasional small necrotic ring. Upon continued serial transfer, this strain tends to induce progressively more severe symptoms; consequently, it was general practice to effect biological purification by serial passage through local lesions on *Gomphrena globosa* L. The strain of PVY used induces in tobacco a prominent veinclearing followed by mild systemic veinbanding and mottle.

Whenever possible, fresh crude juice inocula were prepared from systemically infected leaves from Turkish tobacco plants inoculated 2–3 weeks previously. These leaves were ground either by mortar and pestle or in a food chopper, and the juice was pressed through 2 layers of fine-mesh cheesecloth. For the inoculation of tobacco plants in a given experiment, inocula were adjusted to the same PVX concentration and to the same concentration of crude plant juice; thus, PVX inocula consisted of 1 part juice from PVX-infected plants plus 1 part healthy-plant juice, and PVX-PVY inocula consisted of equal parts of juices from singly infected plants containing the respective viruses.

The test plant used was Turkish tobacco transplanted into steam-sterilized composted soil in 4-in. unglazed clay pots. During fall and winter, seedlings were supplied supplementary light by 500-W Mazda lamps. All plants were given supplementary nitrogen by weekly applications of approximately 0.04*M* NH_4NO_3. The average greenhouse temperature was 21° during winter months; at other times, the daytime temperature often exceeded 32°, especially in the summer.

Plants were inoculated when they had reached the 3- to 5-leaf stage, generally about 7–8 weeks after seeding. Plants for a given experiment were selected for uniformity, divided into 2 groups of 36 plants each, dusted with 400-mesh Carborundum, inoculated by the gauze pad technique, and rinsed immediately with tap water. In one group, 2 or 3 lower leaves of each plant were inoculated with PVX; in the other, comparable leaves were inoculated with a mixture of PVX and PVY. After 24 hours, during which the inoculated plants remained at normal greenhouse temperatures, 18 plants of each group were placed in each of 2 temperature chambers.

In these specially designed chambers, the inside dimensions of which were $36 \times 50 \times 36$ in., temperature was controlled within ±0.5°C by heating and refrigeration units connected to 3-wire double-throw thermostats. Air was circulated continuously (280 cu ft/minute) in the chambers. The potted plants were placed in shallow metal trays containing wet peat moss; plants and peat moss were watered frequently. About 500–600 ft-c of light was supplied for 16 hours each day by a bank of 28 fluorescent tubes (30W) mounted over the top of each chamber and separated from the chamber with window glass so that they could be cooled by small blowers. Four temperatures, 19°, 24°, 28°, and 32°C were used, with any one experiment involving 2 of these. Mechanical difficulties with the chambers resulted in the loss of some experiments involving 24°; thus, data are presented only for the other 3 temperatures. Tobacco plants grew well in these chambers; in tests where chamber and greenhouse temperatures were similar, plants in the chambers were darker green and sturdier than comparable ones growing under normal greenhouse conditions.

At intervals, 1 or 2 leaves from 6 plants from each of the 2 groups in each chamber were selected for assay. Only acute-stage leaves were selected; these were the first uninoculated leaves systemically invaded during the period of rapid expansion. In doubly infected plants, these were easily selected on the basis of symptoms (9) and usually were the 2nd or 3rd above the uppermost inoculated leaf. Since singly infected plants were symptomless or nearly so, "acute-stage leaves" from such plants were selected on the basis of location—corresponding doubly infected plants were used as a guide. Leaves to be assayed were ground either in a food chopper or by mortar and pestle, after which the juice was expressed through 2 layers of fine-mesh cheesecloth. Samples of such juices were suitably diluted with distilled water and used for assay the same morning. In each experiment, assays were generally made on 3 dates at approximately 3- to 4-day intervals.

The assay plant used for determinations of the relative concentrations of PVX was a strain of *Gomphrena globosa* selected for uniformity of reaction to PVX and for ability to produce at least 4 pairs of usable leaves (10, 18). These plants were grown essentially the same as the tobacco; supplementary light was supplied until the plants were used—just before the flowering stage. One or 2 days before inoculation, plants selected for uniformity were decapitated and trimmed to 4 pairs of leaves on the main stem. Twelve plants were used for each assay; the 2-dilution method of Spencer and Price (14), as adapted by Rochow, Ross, and Siegel (10) for use on Gomphrena, was used for all PVX assays.

At the beginning of each experiment, several tubes of crude juice from PVX-infected tobacco leaves were prepared and frozen. These served as a common reference, or "standard," for assays in a given experiment. On each assay date, a tube of this frozen juice was thawed, centrifuged for 15 minutes at 3000 G and then used (after suitable dilution) as a reference inoculum. Rochow, Ross, and Siegel (10) found that this procedure introduced no appreciable error; no evidence to the contrary was obtained in the present study. Each assay compared a test sample with a standard inoculum for that experiment or with another test sample such that each could be related to the standard.

Results.—Fig. 1 is based on the combined data of 2 experiments, one of which compared 19° and 28° and the other 28° and 32°. The data were recalculated so that those for the 3 temperatures and for assays made at different intervals could be plotted on the same relative scale in terms of relative PVX concentration. This was possible because the 2-dilution scheme permits interpretation of lesion counts in terms of relative PVX content. a standard was used for all assays within an experiment, and the 2 experiments

had one temperature treatment in common. Data obtained 13 days after inoculation were incomplete; hence, only the 10- and 17-day data are presented. Results of other similar experiments were in general agreement with the data presented in Fig. 1; since no single pair of experiments yielded a complete set of data, it was not possible to combine the results of all experiments.

At 28° and at 32° the PVX content changed very little after 10 days in either singly or doubly infected leaves (Fig. 1). In contrast, the PVX content of both types of leaves at 19° increased considerably between 10 and 17 days. Results of other tests indicated that after 17 days there is no appreciable increase in PVX in singly infected leaves and no great increase in doubly infected ones, which by then often show extensive necrosis; thus, the 17-day data are regarded as indicative of the maximum (or near-maximum) amounts of PVX synthesis a given type of leaf will support under the conditions used. The 17-day data indicate a very marked effect of temperature on the maximum PVX concentration reached in both singly and doubly infected leaves—the higher the temperature, the lower the maximum. Comparison of the 10- and 17-day data, plus data of other experiments, indicates that an increase in temperature, within the range studied, increased the rate of PVX multiplication during its rapid phase, and decreased the duration of the rapid phase.

The qualitative effects of temperature on PVX multiplication in doubly infected leaves were about the same as those in singly infected ones, i.e., in both types of leaves an increase in temperature decreased the maximum amount of PVX synthesized, increased the rate of PVX multiplication during its rapid phase and decreased the duration of the rapid phase.

The quantitative effects of temperature on PVX multiplication were somewhat greater in doubly infected leaves than in singly infected ones, particularly the effect of temperature on the maximum PVX concentration reached. The tendency of the two 17-day curves to converge at progressively higher temperatures indicates that the ability of doubly infected leaves to synthesize PVX was affected more by temperature changes than was that of singly infected ones. This means that the higher the temperature, the smaller was the excess amount of PVX synthesized as a result of the stimulus of PVY infection. The actual amounts of PVX synthesized as a consequence of PVY infection can be expressed quantitatively in terms of the arbitrary units used for Fig. 1. Subtraction of the 17-day values for singly infected leaves from the corresponding ones for doubly infected leaves shows that PVY infection increased the leaf's ability to synthesize PVX by 545 units at 19°, 340 units at 28°, and 272 units at 32°. Thus the effect of PVY infection on the leaf's capacity for PVX synthesis was about twice as great at 19° as at 32°.

The general effect of PVY infection on PVX synthesis was quite similar to that of a decrease in temperature: both had parallel effects on the rate and extent of PVX multiplication. The quantitative effect

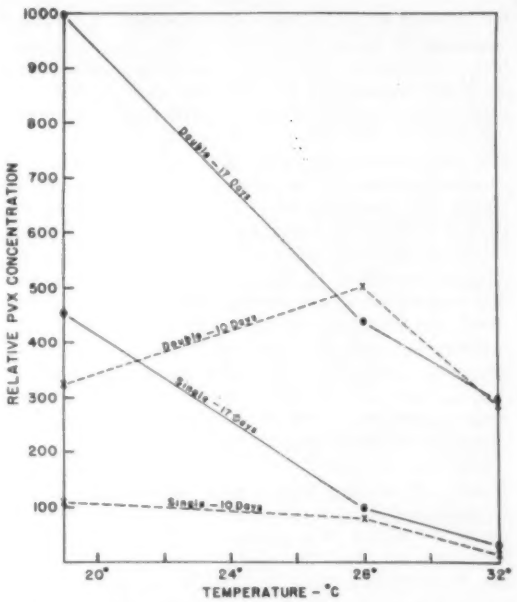

Fig. 1.—Relative concentration of potato virus X (PVX) in juice from the first systemically invaded leaves of tobacco plants inoculated with PVX or PVX + potato virus Y and placed 1 day later at different temperatures. Assays were made on *Gomphrena globosa* 10 and 17 days after inoculation.

of PVY infection on the leaf's capacity for PVX synthesis was approximately equivalent to that of a 9° decrease in temperature within the range studied; e.g., at 17 days, the PVX concentration was similar in doubly infected leaves at 28° to that in singly infected ones at 19° (Fig. 1).

Since Rochow and Ross (9) reported much of their data on the PVX-PVY interaction in terms of the ratio of the concentration of PVX of doubly infected plants to that in singly infected ones (X_{xy}/X_x), we calculated the present data on the same basis. That this ratio increased as the temperature was increased is evident from the 17-day data, which represent the maximum concentrations reached and are not confounded by a temperature effect on the rate of PVX multiplication. On that day, the respective X_{xy}/X_x ratios at 19°, 28°, and 32° were 2.2, 5.0, and 11.5. These data, although seemingly contradictory to the interpretation given above, do not necessarily mean that the extent of the PVX-PXY interaction increased as temperature was increased; it is clear that the gradient shown by the ratios was largely determined by the values for X_x, which varied with temperature to a much greater extent than did the quantity of the excess PVX formed as a consequence of infection by PVY.

One experiment in the present series involved alternating temperatures, since Rochow and Ross (9) postulated that high X_{xy}/X_x ratios perhaps result from a proper balance of alternating high and low temperatures. One group of plants was maintained at 32°

for 15 hours of each 24-hour period and at 20° for the remaining 9 hours. A second group of plants was held continuously at 32°. The low-temperature period coincided approximately with the dark period. In plants subjected to alternating temperatures, the concentration of PVX was much higher in both singly and doubly infected leaves than in leaves of corresponding plants held at constant 32°, but in leaves of plants held continuously at 20° was lower than expected from other experiments. The X_{xy}/X_x ratios for leaves maintained under the alternating conditions were not as high as for leaves at constant 32° but were higher than those obtained in other experiments in which temperatures near 20° were used. These data indicate that allowing the temperature to fluctuate between 2 temperatures does not necessarily result in X_{xy}/X_x ratios that exceed those expected at the higher temperature or in PVX levels that exceed those expected at the lower temperature.

Another experiment was designed to determine whether the adverse effect of high temperature on PVX accumulation in plants held at 32° persists when such plants are moved to temperatures more favorable for PVX multiplication. One group of plants, half of them singly infected and half doubly infected, were held at 28° throughout the experiment; a similar group was held at 32° for 10 days and then at 24° for another 10 days. The change was made at 10 days, for PVX concentration had reached a maximum by 10 days in other experiments at 32°. Assays made of acute-stage leaves 5 and 10 days after removal to the lower temperature showed that PVX accumulation had resumed in the plants previously held at 32°. By the last assay, the PVX concentration in singly infected plants was about 1.6-fold higher in the leaves of plants moved from 32° to 24° than in those of plants held at 28° throughout. The PVX content of the doubly infected leaves was about the same at the 2 temperatures. Thus it is evident that 10 days at 32° had no lasting limiting effect on PVX synthesis. Whatever the nature of the mechanism that sharply limits virus synthesis at 32°, it evidently does not alter the virus synthesizing system permanently.

In general, severity of symptoms resulting from a given type of infection (single or double) was correlated positively with PVX concentration. Symptoms of single infections were very mild at all temperatures, but a tendency for symptom severity to increase with a decrease in temperature could be detected by close examination. In double infections, the most severe symptoms were observed in acute-stage leaves of plants held at 19°; those at 32° were practically symptomless. Symptom severity and PVX concentration were not correlated, however, when singly infected leaves were compared with doubly infected ones. For example, double infection at 28° and single infection at 19° resulted in comparable PVX concentrations but markedly different symptoms—the former induced mild to moderate veinal necrosis and puckering, and the latter a very mild mottle. Symptoms generally appeared first in plants held at 28°. The 19° plants were significantly smaller than those held at either of the two higher temperatures, but the 32° and 28° plants became senescent before those held at 19°.

Discussion.—Our data on the effect of temperature on the multiplication of PVX in single infections are in accord with those of Pound and Helms (6), despite the use of different sampling and assay procedures. When their data for maximum PVX concentrations at 20°, 24°, and 28° are plotted in a manner similar to that used in our Fig. 1, the curve obtained is similar in shape and slope to that given by our data for single infections on the 17th day.

The fact that temperature has a marked effect on the X_{xy}/X_x ratio may possibly account for the seasonal variation in this ratio noted by Rochow and Ross (9). High ratios were obtained in the spring and fall, periods when the Cornell greenhouses are usually without shade and are heated at night. Thus the average temperature may have been higher than usual because of high daytime temperatures and nighttime temperatures near 21°.

Although the present data show that the X_{xy}/X_x ratio is not always a good index of the interaction between the two viruses, this fact does not invalidate conclusions based on earlier work (7, 8, 9, 10, 11, 12, 13) where results were expressed as ratios. The variations in X_x encountered in the earlier work were not nearly so great as those recorded here, and quite often X_x was high where the ratio was high.

It is possible that the different PVX concentrations recorded at different temperatures reflect differences in the amount of virus inactivated rather than differences in the amount of virus synthesized. Although this may be true in part, it seems improbable that the major differences are actually the result of differences in the amount of virus inactivated. Throughout all of the PVX-PVY investigations at Cornell, PVY-induced increases in PVX concentration have always been accompanied by increases in symptom severity. Furthermore, increases in symptom severity have been roughly proportional to the increases in PVX concentration. It seems reasonable to assume that symptom severity is more directly related to virus synthesis than to net accumulation of virus. The near absence of symptoms at 32° is therefore interpreted as an indication of limited PVX synthesis at this temperature. Furthermore, we consider it very unlikely that PVX is inactivated more rapidly in singly infected plants than in doubly infected ones to an extent that would account for the large differences in the PVX content of the two kinds of plants. These differences, which sometimes are greater than 10-fold, arise during the rapid phase of PVY synthesis (9). It is very unlikely that a decreased rate of inactivation of PVX during this comparatively short period could account for such a large difference in PVX content.

The extent to which PVY infection increases the amount of PVX synthesis that a leaf will support appears to be unrelated to the actual amount of PVY synthesized by the leaf, for the two effects differ in their temperature dependency. Previous data (9), however, had suggested such a relationship: large increases in the leaf's ability to synthesize PVX were

obtained only in leaves in which PVX was present when PVY was undergoing rapid multiplication. These seemingly contradictory data, all obtained with leaves that were rapidly expanding when invaded by PVY, suggest that perhaps the determining factor is not the extent of PVY multiplication but instead the activity of the synthesizing processes of the cell at the particular time when PVY invasion occurs and the extent to which this is altered during the period of rapid PVY multiplication. Perhaps PVY, by multiplying in a cell during a stage of the cell's development when its synthesizing mechanisms are highly active, changes these mechanisms in a way that enables PVX, if present at that time, to multiply more extensively than in an unaltered cell. Thus, in effect, PVY multiplication *per se*, if occurring at the proper time, may alter the cell physiology so that the mechanism normally limiting PVX synthesis becomes operative only at a higher level than it does in an unaltered cell or so that some other mechanism becomes the limiting one.

Just what the nature of this hypothetical change might be is obscure. It could be an increase in the supply of a material that is limiting for PVX synthesis, a change in the amount and/or action of self-inhibitors produced during PVX synthesis, or provision of new multiplication sites for PVX. A plausible hypothesis that we believe will explain all of the available data is 1) that PVX synthesis in singly infected plants is limited by the availability of a particular plant metabolite; 2) that PVX synthesis does not compete strongly with normal plant processes for this metabolite but instead uses that not required for maintenance of a near-normal plant; 3) that an increase in temperature (within the 19-32° range) accelerates plant utilization of the metabolite (or otherwise depletes the supply) and hence diminishes the amount available for PVX synthesis; 4) that PVY infection, if established at the proper time, changes the rate of plant utilization and/or formation of the metabolite to an extent that results in a temporary accumulation of a large excess, allowing PVX, if present at that time, to multiply until a second specific metabolite becomes limiting for PVX; and 5) that utilization of the second metabolite for PVX synthesis is in competition with, or at the expense of, plant utilization and hence results in damage to those tissues requiring it most for their development and functioning.—Department of Plant Pathology, Cornell University, Ithaca, New York.

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BOOK LISTING

Diseases and pests of ornamental plants.—*Pascal P. Pirone, Bernard O. Dodge, and Harold W. Rickett.* 1960. Third edition. The Ronald Press Co., New York, N. Y. 775 p. Price $10.00.

This volume, an expanded edition of Dodge and Rickett's book of the same name, is divided into 2 parts. Part I (134 pages) contains 4 chapters, dealing with the following subjects: 1) infectious diseases classified by symptoms, and diseases due to environmental conditions and cultural practices, 2) bacteria and fungi, 3) insects and other animal pests, and 4) control. Part II (591 pages) lists the disease and pests of particular plants. The plants are arranged alphabetically according to their generic names. A subject index of 46 pages is also provided.

THE ROLE OF AMYGDALIN BREAKDOWN IN THE PEACH REPLANT PROBLEM

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SUMMARY

Hydrolysis rates of amygdalin and the resulting production of HCN were rapid in peach replant problem soils, peach nonreplant problem soils, and soils cultivated to crops other than peaches. Rate of breakdown of amygdalin (determined quantitatively by measuring oxygen uptake in a Warburg respirometer or qualitatively by the sodium picrate paper method) varied significantly only with soil depth. Deeper soils showed less activity. Thus it is theorized that amygdalin breakdown probably does not account for the difficulty of establishing peach trees in certain old peach soils in some areas of California. Amygdalin additions to nonautoclaved soil were toxic to growing peach seedlings, but if a 14-day period elapsed between these additions and planting, tests for cyanide were negative and cyanide injury was not evident.

Young peach trees are often established with considerable difficulty in old peach orchard sites. This has been referred to as the peach replant problem (6). Since the problem is not universal in old peach orchard soils, the terms "replant problem soil" and "nonreplant problem soil" are used in this paper. Replant problem soil refers to areas where replanted trees grow abnormally, and nonreplant problem soil supports normal growth of replanted trees.

The theories advanced as to the cause of this problem and symptomatology were reviewed by Patrick (5).

Amygdalin is a cyanophoric glycoside that is enzymatically broken down into glucose, benzaldehyde, and hydrogen cyanide. Amygdalin is known to exist in the fresh roots of peach trees in concentrations as high as 50 mg/g of dry tissue (9). Since hydrolysis yields cyanide, which is toxic to the growth of plants (2, 3), this has been considered a factor in the depression of growth of peaches in old peach soil (5).

Much of the work dealing with the toxicity of cyanide to plants, however, has been done in various nutrient solutions. Proebsting and Gilmore (6) showed that peach trees were injured when amygdalin and emulsin or KCN were added to seedling trees growing in nutrient solutions. Patrick (5) emphasized the importance of microbial action on the amygdalin fraction of peach roots and suggested that the main cause of the toxicity frequently encountered in old peach orchard soils is breakdown of amygdalin. He found that organisms able to utilize amygdalin were present in higher proportion in the site area than in intersite areas. Further, when amygdalin was added to soil from the intersite area, decomposition seldom took place (tests for cyanide were negative).

The presence of the replant problem in some California old peach soils and not in others may indicate that amygdalin breakdown differs in these areas, as reported by Patrick in Canada.

This paper reports on experiments conducted to determine if amygdalin breakdown occurred in typical peach replant problem soils, nonreplant problem soils, and nonpeach soils. Also included are studies on amygdalin toxicity and duration of toxicity to peach seedlings in soil.

Materials and methods.—Two methods were used to determine amygdalin breakdown in soil: a) determining the production of HCN by the sodium picrate paper method (1), and b) measuring oxygen uptake in a Warburg respirometer (7). Aqueous solutions of chemically pure amygdalin were added to the soil samples for both studies. Soils were randomly selected from several locations in the orchard, pooled, and then subsampled. The soils were obtained from orchards where replanting was a problem, where replanting was not a problem, and from nonpeach soils.

For the determination of HCN by the sodium picrate paper method, aqueous solutions of amygdalin were added to the air-dried thoroughly mixed soils so that the concentration of amygdalin ranged from 312 to 2400 ppm based on dry soil weight. The tests were run in capped 125-ml Erlenmeyer flasks at 30°C. generally for 12 hours, after which time the papers were removed and read.

For the Warburg studies the following materials were added to each flask: 1) 5 g air-dried soil, 2) 0.5 ml 20% KOH in the center well with fluted filter paper, and 3) enough water, 0.1*M* glucose, or 0.1*M* amygdalin to saturate the soil. The glucose series and the water series without carbon were added for reference points and as checks. Oxygen uptake was measured every hour at 30°C, usually for a 9-hour period after 20 minutes for equilibration. Flasks were run in duplicate, and the results were plotted as μL of oxygen uptake versus time per 5 g air-dried soil.

Other studies were initiated to see if amygdalin additions to soil were toxic to growing peach seedlings and how long any toxicity remained. Aqueous solutions of chemically pure amygdalin were added to soils to bring them to field capacity and to set the concentration of amygdalin at 2500 ppm on a dry-weight basis. Amygdalin and sterile water only were added separately to nonautoclaved and autoclaved soil. Seedling peaches were placed in the soils in No. 4 Coors crucibles. All containers were covered with large glass cylinders to prevent contamination. HCN was determined by hanging sodium picrate papers in the containers. After 6 days, amygdalin solution and water were replenished. After 10 days, the seedlings were removed and washed with water, and observations made.

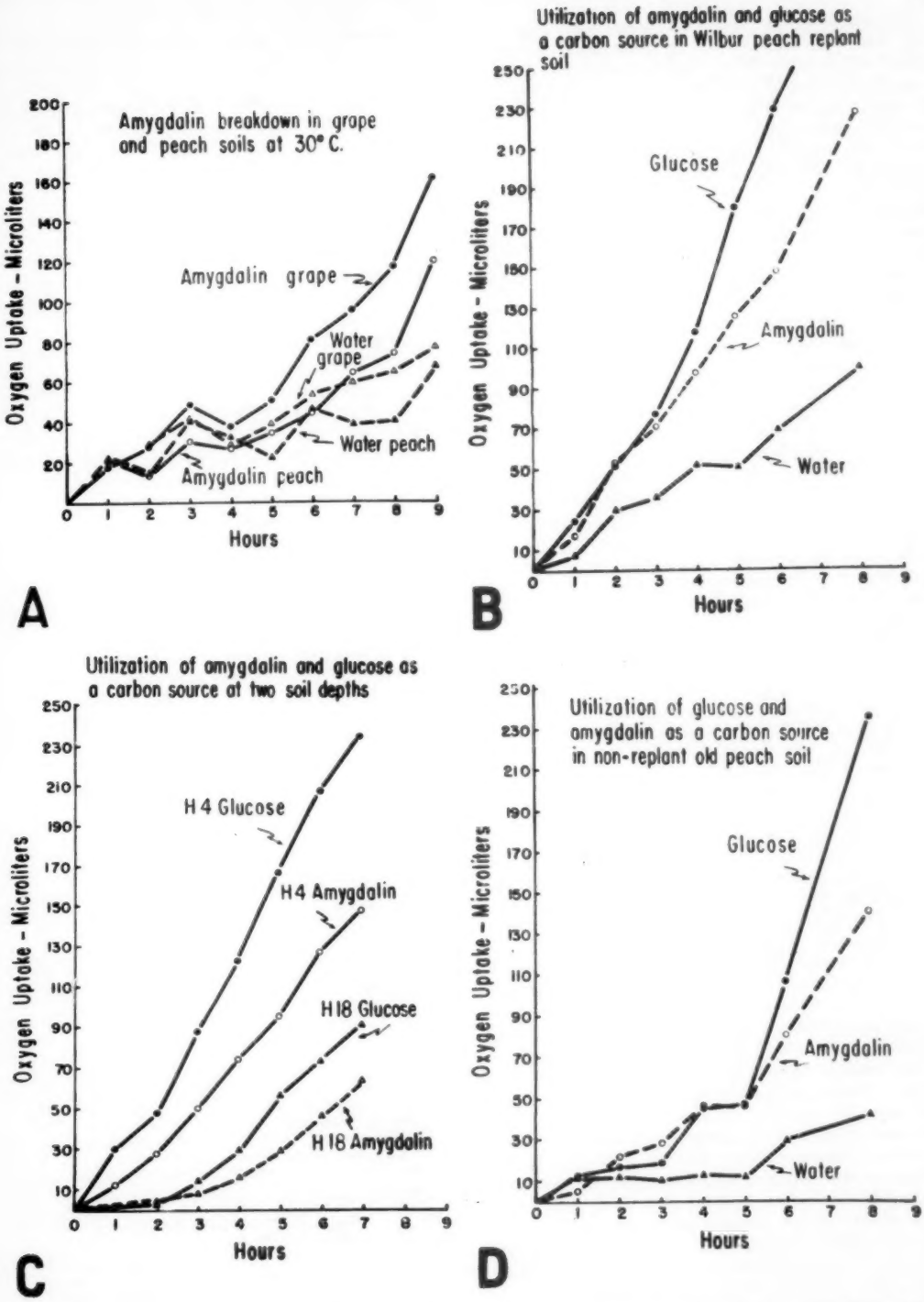

Fig. 1.—Utilization of amygdalin by soil microorganisms. **A)** Comparison between a grape and a peach soil with long histories of single cropping. **B,C)** Comparison of amygdalin and glucose as carbon sources for microorganisms in (B) peach replant problem soil and (C) nonreplant problem soil. **D)** Comparison of amygdalin and glucose as carbon sources in old peach nonreplant problem soil at two soil depths.

Certain fungi isolated from peach roots and from soil were compared for ability to break down amygdalin and produce HCN. Soil was air-dried and autoclaved for 2 hours at 15 lb. Ten grams were placed in sterile 125-ml Erlenmeyer flasks in duplicate. A sterile aqueous solution of amygdalin was added to bring the concentration to 0.25% amygdalin on a dry-weight basis and to bring soil moisture to about field capacity. A 4-mm disc from an agar culture of each fungus was transferred aseptically to the flasks. Sodium picrate papers to detect HCN were hung in the flasks, which were then sealed with rubber stoppers. Checks were made by adding sterile water or glucose to the flasks instead of amygdalin.

Results.—Amygdalin breakdown and production of cyanide took place rapidly in all soils tested by the sodium picrate paper technique. Past cropping history made no difference. Tests for cyanide were negative in autoclaved soil with added amygdalin or soil with glucose or water added instead of amygdalin.

Results of the Warburg studies are shown in Fig. 1-A,D. Fig. 1-A shows that breakdown rates of amygdalin are similar in adjacent fields with long histories of grape and peach culture. Fig. 1-B illustrates oxygen uptake rates on addition of glucose and amygdalin in a typical replant problem peach soil, and Fig. 1-C compares nonreplant problem soil. Breakdown of amygdalin and glucose in an old peach nonreplant problem soil at two soil depths is shown in Fig. 1-D.

If a comparison is made between Fig. 1-C (a typical nonreplant problem peach soil where peaches had been grown continuously for 40 years) and Fig. 1-B (a replant problem soil where peaches had been cultivated for the same length of time) it can be seen that after 5 hours amygdalin additions caused very similar oxygen uptake in both the replant problem soil (1-B) and the nonreplant problem soil (1-C).

It is assumed that increase of oxygen uptake on addition of aqueous solutions of amygdalin to soil is an indication of amygdalin breakdown. This is substantiated by the fact that tests for cyanide by the sodium picrate paper technique were always positive under the same conditions.

Fig. 1-C demonstrates a higher degree of biological activity from surface soil than soil collected at deeper levels as shown by oxygen uptake activity on additions of glucose. Although HCN is a respiratory poison, the small quantities produced in the Warburg flask did not appear to inhibit biological oxidation; the slopes of the amygdalin curves roughly parallel those of glucose.

Amygdalin added to nonautoclaved soil was toxic to growing peach seedlings. Root systems were badly decayed or totally destroyed in 10 days. Most of the root systems in nonautoclaved field soil with only water added showed lesions, browning, and destruction of rootlets. The damage, however, was not as severe as when amygdalin was added. Root systems were healthy in all of the autoclaved series.

When germinated peach seeds were placed in soil 14 days after amygdalin had been added, the roots showed no more browning or destruction than did the roots of seedlings grown in field soil with only water additions. They were not as seriously damaged, however, as seedlings grown in field soil with added amygdalin but without a 14-day delay in planting. Tests for cyanide were negative at 14 days, indicating that amygdalin breakdown was complete before the seeds were planted.

Pythium isolates from various peach replant sites, whether from roots or from the soil, induced HCN production when introduced into sterilized peach soils to which 0.25% amygdalin had been added. Isolates of *Fusarium oxysporum* and *Rhizoctonia* sp. did not induce HCN production.

Quantitative studies on the utilization of amygdalin as a sole carbon source in a minimal medium revealed that Pythium isolates used it as a carbon source only when sucrose was offered with amygdalin. In such cases the test for cyanide was positive.

Discussion.—Many roots are left in the soil when trees are removed and sites prepared for replanting. The quantity of roots remaining would be the same in replant problem and in nonreplant problem areas. Since amygdalin content of roots would be a constant factor and hydrolysis rates were shown to be rapid in both types of soil (Fig. 1-B,C,D), it does not seem probable that this is the factor responsible for the replant problem.

In addition, little decomposition of amygdalin could be detected in soil collected below 18 in. Very few large roots will be apt to remain this close to the surface if trees are removed by the usual bulldozing or pulling methods, and small roots in the upper 18 in. will decompose rapidly. Deeper roots would decompose slowly, but there would be few amygdalin decomposers there to produce HCN.

The breakdown of amygdalin was due to microbial activity since no HCN was ever detected in autoclaved soil. The decrease in rate of amygdalin hydrolysis with increases in soil depth is probably correlated directly with the total number of microbes, which is known to decrease as depth increases (8).

The probable role of fungi in the replant problem will be discussed in a later report.—Department of Plant Pathology, University of California, Davis.

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SOMATIC RECOMBINATION IN PUCCINIA GRAMINIS VAR. TRITICI

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SUMMARY

Recombinants, identified on the basis of color and pathogenicity, were obtained when urediospores of *Puccinia graminis* var. *tritici* culture 111 were mixed with urediospores of 6 other cultures and inoculated onto wheat seedlings. The variety that was inoculated with the urediospore mixtures appeared to have a qualitative selective effect on the recombinants recovered. Pathogenicity on several of the host varieties is controlled by more than one gene locus, since 5 distinctive reaction types on one variety were observed among the recombinants of one mixture.

Introduction.—Recent investigations (1, 2, 6, 7) have demonstrated that new races of *Puccinia graminis* Pers. var. *tritici* (Eriks. & E. Henn.) Shear, Ball, Jacks., & Stakman can arise following the inoculation of wheat plants with a mechanical mixture of urediospores of 2 or more races. The germ tubes of urediospores from different races fuse, allowing nuclei from the 2 races to be present in a common cytoplasm (9). What happens following anastomosis of germ tubes is not precisely known, and the genetic data have been explained in several ways: reassortment of whole haploid nuclei to give rise to unstable trikaryons or stable dikaryons (2, 6), parasexualism, or cytoplasmic effects (1, 6).

This paper records recombinants obtained when urediospores of the highly avirulent culture red 111 were mixed with urediospores of each of 4 orange cultures, 1 gray-brown culture, and another highly avirulent culture, red 262.

Materials and methods.—Seven cultures of the rust fungus were used in mixtures. The cultures and their respective urediospore colors were: 111 and 262 (red), GB 121 (gray-brown), OR 4, OR 9, OR 11, and OR NR-2 (orange).

Mixtures of urediospores of 2 cultures were suspended in a light mineral oil (Mobilsol 100) and inoculated onto seedlings with a microatomizer. The inoculated plants were placed in a moist chamber for 12 hours, allowed to dry slowly for 2–6 hours, placed under a light intensity of 1000 ft-c for 2–4 hours, and then placed on a greenhouse bench (4).

The new recombinants were found when the urediospore mixtures were inoculated onto wheat varieties Reliance, Arnautka, Spelmar, and Bowie, varieties on which red 111 was avirulent. Red color, dominant to orange or gray-brown, was used together with pathogenicity in the selection of recombinants. Thus recombinants appeared as large red uredia.

The recombinants were increased on Little Club wheat, and each was inoculated 1–3 times onto a set of 54 varieties of wheat. The varieties on which the recombinants were distinguished were inoculated again and placed on a greenhouse bench grouped according to wheat variety. In this direct comparison test, significant differences could be noted among cultures, since all were treated in the same manner and placed adjacent to each other in the greenhouse. When handled in this manner, differences in reactions between the cultures and a wheat variety must be due to genotype of the fungus. Even though the infection type of some culture-variety combinations can be altered by changes in temperature, all cultures were exposed to a similar environment. Only results from the direct comparisons are presented here.

Results.—The number of recombinants from each of the 6 mixtures was: red 111 and GB 121, 1; red 111 and OR 11, 2; red 111 and OR NR-2, 5; red 111 and red 262, 15; red 111 and OR 4, 15; red 111 and OR 9, 19. In each of the mixtures all the recombinants were distinct from each other; no two cultures were identical. Furthermore, all recombinant cultures from all mixtures were distinct. It would be possible to account for the origin of the recombinants of the first 2 sets of mixtures by assuming reassortment of whole nuclei. Such an explanation is not possible, however, when more than 4 different entities arise, as happened when the last 4 mixtures were made.

In the 6 different mixtures described here, the high frequency of progeny with greater virulence than the parental cultures on one or more varieties was very pronounced. All of the progenies of the 6 different mixtures have been more virulent on one or more varieties on which neither of the parent cultures was highly virulent.

Neither OR NR-2 nor red 111 was virulent on

varieties Arnautka, Bowie, or #21 (selection from Thatcher × Timstein × Premier). Of the 5 progenies from the mixture: all were virulent on Arnautka, 4 were virulent on Bowie, and 3 were virulent on #21. Therefore the parental cultures possess genes for virulence that are not expressed in the parental genotypes. Both of the parental cultures could possibly have been carrying genes for virulence on these varieties but culture red 111 must at least have had genes for virulence on Arnautka, since all progenies from all 6 mixtures were virulent on that variety.

The variety on which the recombinants appeared had an effect on the recombinants recovered. In the mixtures involving OR NR-2 and red 111 the 4 progeny were selected on variety Bowie and all were highly virulent on Bowie. The one selected on Arnautka was only slightly more virulent on Bowie than the parents. Results were similar with other mixtures.

Cultures OR-4 and red 111 are both weakly virulent on Bowie: OR-4 produces a small uredium with much necrosis adjacent to the uredium, and red 111 produces only a fleck. From the mixtures of these two cultures 15 recombinants were obtained; 6 were similar in that they were highly virulent on Bowie and on several other varieties, 4 produced the mesothetic reaction (5) with much necrosis on Bowie, and 5 were weakly virulent on Bowie and several other varieties. The five weakly virulent cultures could be further subdivided on the basis of the position of the necrosis with respect to the minute uredium produced: 3 with green tissue adjacent to the uredia but surrounded with a necrotic ring, and 2 with necrosis immediately adjacent to the uredia. On the variety Selkirk, 5 types of reactions were present: 1) large uredia with adjacent green tissue, 2) large uredia with adjacent area chlorotic, 3) a mesothetic reaction, 4) a mesothetic reaction with varying degrees of necrosis about both large and small uredia, and 5) a small uredium with adjacent green tissue surrounded by a necrotic ring. The reactions of the cultures with Bowie and Selkirk were clearly distinguishable in the direct comparison tests.

Discussion and conclusions.—From the data presented, the variation observed among the progeny in 2 of the 6 mixtures can be explained by simple reassociation of the nuclei in pairs. To explain the variation in the other 4 mixtures it is necessary to postulate that some other or additional mechanism is present whereby recombination may occur between nuclei in the somatic tissue.

Parasexuality has been postulated as one of the mechanisms whereby the new recombinants arise (6, 7). In the parasexual cycle as described by Pontecorvo (3) there is a propagated diploid phase, followed by somatic crossing-over and the haploidization process that involves segregation of whole chromosomes. A diploid phase, though it must occur to recombine the genes for virulence, has not been observed cytologically, and must be of short duration. There is no evidence at present for a prolonged diploid phase in rusts.

Another possible explanation is the occurrence of a meiotic phenomenon in somatic tissue. In such a process the haploid nuclei could fuse and immediately undergo meiosis with segregation of genes on the same or different chromosomes. Determination of the processes actually involved here, parasexuality vs. a meiotic phenomenon, must await genetic analysis of the isolates via the standard sexual cycle and an understanding of the mode of inheritance of pathogenicity with all the gene interactions.

It is obvious that some cultures of the rust fungus carry genes for virulence that are not expressed until recombined. Furthermore, as many as 5 different reactions were observed between the progeny of 1 cross and a particular host variety. Five different reactions can be explained only by assuming that more than one locus is involved in the host-parasite reaction and that the different loci govern different parts of the host-parasite reaction. The 4 types of reactions that were observed between the recombinants of the mixture OR-4 and red 111 with variety Bowie could be explained by the reassortment of a minimum of 2 interacting loci. Three loci would be required to explain the 5 types observed with the same recombinants and Selkirk, the difference between the 2 types of mesothetic reactions being the presence or absence of the necrosis surrounding all uredia.

One of the questions that arises concerns the presence of recombination only when cultures were mixed. There should be ample opportunity for recombination in one culture of the fungus as each cell of each culture contains 2 haploid nuclei. In each culture that is heterozygous for at least one gene, it should be possible to get homozygous segregants in subsequent generations. In this study, no segregants were observed unless the cultures were mixed. All the orange, gray-brown, and red cultures used in these experiments remained stable. That culture red 111 is heterozygous for several genes is known (8), and easily observed from the data presented here. Recombination, however, may be occurring in both individual cultures and in mixtures of cultures, but with selection between nuclear pairs playing a dominant role in the selection and survival of recombinant nuclei. Recombinants may therefore have a selective advantage when more than 2 genomes are present within a cytoplasmic membrane, as occurs following anastomosis of urediospore germ tubes.—Department of Plant Pathology and Botany, Institute of Agriculture, University of Minnesota, St. Paul.

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EFFECT OF SOURCE HOST ON INFECTIVITY OF TOBACCO MOSAIC VIRUS ISOLATES

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SUMMARY

A standard tobacco mosaic virus isolate purified from tobacco was passed through other hosts. When the virus was repurified from these hosts and tested on cucumber for infectivity at equal optical densities of the purified preparations, the relative infectivity was found to depend on the host from which the virus was reisolated. Local-lesion hosts tended to confer a lower order of infectivity on the isolate than did systemic hosts. Neither age of infection nor total virus titer in a host had any influence on infectivity. Of the 8 hosts studied, *Physalis floridana* yielded the most infective preparations, and Pinto bean the least infective. Virus was 250 times as infective from the former host as from the latter.

In studies on the relative infectivity of virus isolates, we have found that the infectivity is influenced by the host from which the virus was isolated. Since this host-induced effect did not appear to be generally recognized, it seemed desirable to call the effect to the attention of other workers.

Most workers have recognized that when unpurified leaf extracts are used for virus inoculum, the presence of inhibitors may alter the infectivity of such inocula (1), and that purified virus isolates are necessary for comparative tests of infectivity.

It is also known that the relative infectivity of a virus isolate is dependent on the assay host used. Thus, certain naturally occurring strains of TMV (tobacco mosaic virus) may infect *Nicotiana glutinosa* L., but not bean (6, 13). Similarly, isolates from nitrogen-deficient plants (5, 17) or certain chemical derivatives of TMV with altered virus protein (14), may have a lower infectivity than normal isolates on bean but not on *N. glutinosa*.

It has long been recognized that a virus may be "attenuated" by passage through a given host (4), and that the milder form may be restored to the original by passage through a new host (9, 10). This "attenuation" may be due to a separation of strains by a given host because the host favors the replication of one strain from a strain mixture in the inoculum (7). In more recent studies, reversible strain changes were explained on the basis that a host favors variants that originated in it (2, 3).

Another host-induced effect was observed when virus-infected plants were grown at relatively high temperatures (8, 12). In this case, virus infectivity was lost much more rapidly than serological titer. It is not clear whether this host-induced effect was due to an accelerated strain separation by the higher temperature or to some other host-induced effect that was a function of temperature.

In our experiments, a common strain of TMV was isolated from infected tobacco (*Nicotiana tabacum* L. var. Turkish) by repeated differential centrifugation of a heat-clarified leaf homogenate (16). The concentrated stock solution was kept at 4°C, used in appropriate dilution to infect other hosts, and also used as a standard for comparing the infectivity of various isolates. Inoculations to other hosts were made by the rubbing technique with standardized cloth pads saturated with inoculum containing 5% Carborundum by weight (11). Hosts included *Physalis floridana* Rydb., *P. longifolia* Nutt., tomato (*Lycopersicum esculentum* Mill. var. Marglobe), *Nicotiana glutinosa* L., *N. tabacum* L. var. NN, cucumber (*Cucumis sativus* L. var. Chicago Pickling), and bean (*Phaseolus vulgaris* L. var. Pinto). Two to three weeks after inoculation, infected leaves were harvested and frozen, and the virus was isolated from heat-clarified leaf homogenates by repeated differential centrifugation following the procedure used for the original tobacco isolate. Infectivity measurements were made after adjusting the virus concentration of the host isolates and the standard preparation to equal values spectrophotometrically (18). Cucumber was the host for infectivity assays. One cotyledon was inoculated with the standard virus preparation, and the opposite cotyledon was inoculated with the test isolate (11). At least 20 replicates were used for each test.

The results (Table 1) clearly show that the infectivity of a given isolate is influenced by the host from which it is isolated. This is particulary true of the

Table 1.—Relative infectivity of TMV on cucumber after passage through various hosts compared at equal optical densities with the original source isolate from Turkish tobacco.

Isolate source	Number of isolates	Range of total titer (μg/gm)	Relative infectivity ± standard error
Turkish tobacco	Standard	Standard	100
Physalis floridana	8	1,720–11,500	125±8
P. longifolia	3	3,010–5,200	66±14
Marglobe tomato	4	115–824	62±9
Chicago Pickling Cucumber	2	24–32	30±8
Nicotiana glutinosa	2	8–176	16±4
NN tobacco	2	134–212	11±0
Pinto bean	2	2–4	0.5±0.2

local-lesion hosts, which yield isolates with a low order of infectivity. Neither the age of the infection nor the total titer in a given host had any influence on the infectivity of the isolate. The local-lesion hosts, of course, had lower titers than systemic hosts. It is unlikely that infection inhibitors have a part in these results, because normal host tissues, when run through the TMV purification procedure, have no effect on TMV lesions when mixed with inoculum.

Present information does not permit a decision as to whether this host-induced effect on infectivity was due to: 1) a separation of an original strain mixture by a given host that favored a strain with low infectivity on cucumber, 2) a separation by a host of mutant strains that arise naturally in that host, 3) a host-induced mutation of the virus, or 4) production of "incomplete" or "uninfective" virus particles by certain hosts.

A phenomenon that may be related to that reported here is found in the report that there is in NN tobacco infected with TMV a zone of tissue around the local lesion that is not susceptible to reinfection by TMV but is susceptible to other viruses (15). It is possible that this zone contains a modified form of TMV that has a low order of infectivity, thereby protecting the zone from reinfection.—Washington State University and Crops Research Division, ARS, U.S.D.A.

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BOOK LISTINGS

Zemedelská Fytopatologie, Díl 1. (*Agricultural Phytopathology, Vol. 1*). 1959. 704 p. Academy of Agricultural Science and State Agricultural Publishing House, Prague, Czechoslovakia. No price mentioned.

This volume consists of a preface, by E. Baudys, and 5 sections, as follows: Diseases caused by deficient nutrition, by V. Vorisek; different groups of pathogens, by B. Kvicala (viruses), F. Mráz (bacteria and actinomycetes), V. Vacek (myxomycetes), J. Spacek (fungi), A. Vezda (lichens), and F. Kühn (parasitic phanerogams); symptomatology, by J. B. Novák; control, by J. B. Novák and K. Dvorák; introduction to phytopathological technique, by J. Benada, F. Mráz, and J. B. Novák; and sources of information (literature and herbaria, by Z. Sesták and V. Skalicky. A list of references is given at the end of each chapter, and a general index is supplied.

Handbook of Mycology.—*M. N. Kamat.* 1959. Part I. Phycomycetes and Ascomycetes. Prakash Publishing House, 360 Budhwar Peth, Poona 2, India. 184 p. Price about $5.00.

A combination textbook–laboratory manual designed for use in a practical mycology course for graduate students at Poona University. Directions and references are given for the study of fungi chosen to illustrate families of each class. Numerous line drawings of representative species accompany each laboratory exercise. Also included are abbreviated sections on mycological technique, a key to important genera of Ascomycetes and Phycomycetes and a list of important diseases of crop plants caused by the two classes.

THE PATHOGENICITY, DISTRIBUTION, AND CONTROL OF TWO RACES OF FUSARIUM (HYPOMYCES) SOLANI F. CUCURBITAE

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SUMMARY

Isolations from cucurbit fruit grown for market and for seed in California have yielded 2 (cucurbit) pathogens of the genus *Fusarium*. One was the well-known root-, stem-, and fruit-rotting form *Fusarium solani* f. *cucurbitae*, now designated race 1; the other, herein designated *F. solani* f. *cucurbitae* race 2, was morphologically similar but pathogenically different in that it attacked only the fruit of cucurbits. Both races are seed-borne to a high degree and occur on and in the seed. In the latter case they lie dormant between the seed coat and the cotyledons and are therefore beyond the reach of ordinary surface-disinfestants. The viability of such infected seed is not impaired, and their germinability remains generally unaffected. Following planting, the fungi establish themselves in the soil. Race 2 does not parasitize the growing plant until the fruits are maturing; then, if the soil surface is moist, it invades the fruit and penetrates the seed, thus completing its disease cycle. Race 1 attacks the growing plant at any time following seed germination and up to and including the period of fruit maturation, causing a cortical rot of the stem. Both attack fruit in the same manner, causing similar dry rots. Race 1 was pathogenic in varying degrees to more than 60 varieties of watermelon, muskmelon, and cucumber, and nearly 100 varieties of squash and pumpkin tested in the greenhouse. In the field, however, the disease has not been found on watermelons although they were susceptible in greenhouse tests, and, of the muskmelons, only the Honeydew and cantaloupe were attacked. Likewise, some of the less susceptible squashes and pumpkins in greenhouse tests have not been found attacked in nature. Cucumbers grown in commercial greenhouses have occasionally been severely attacked. The disease can be controlled by examining the underside of the fruit on the ground and harvesting only the sound fruit, followed by a mercuric chloride soak to disinfest the surface of seeds contaminated with spores during threshing and washing. A four-year cucurbit-free rotation will also reduce the disease caused by race 1 to a point where it is no longer of importance. The two races cannot be distinguished with certainty by their asexual spores or their perithecia. Both are heterothallic and exhibit a great range in variability. They have the same perfect stage in *Hypomyces* but do not cross with each other.

In 1932, Doidge and Kresfelder (6) characterized the root rot of squash and demonstrated the pathogenicity of the South African clone of the *Fusarium*, carried under the name of *F. javanicum* Koord v. *theobromae* (App. & Strk.) Wr. They inoculated several cucurbits successfully, including pumpkin, marrow, and squash. Since then the disease has been reported from New York (2), Canada (16), Connecticut (7), and Australia (3, 4). The disease was first reported in the United States by Snyder (12), who observed it attacking varieties of *Cucurbita pepo* L., *C. moschata* Duchesne, and *C. maxima* Duchesne in California, causing losses of up to 75% of the stand. Snyder and Hansen (14) subsequently studied the morphology and pathogenicity of the causal organism and erected the trinomial *Fusarium solani* App. and Wr. f. *cucurbitae* Snyd. & Hans., indicating the pathogenicity of this particular *F. solani* to cucurbits. Their work showed that the South African, Italian, Australian, and North American isolates were interfertile and were clones of the same fungus.

Recently, during a survey of the disease in California, isolations were made from typical lesions of *F. solani* f. *cucurbitae*, on fruit of Italian Edible gourd (*Lagenaria* sp.) and White Bush Scallop (*Cucurbita pepo*) obtained from fields in Stanislaus county, where the fruits were grown for seed. These isolations yielded, in addition to the cucurbit pathogen, another undescribed *Fusarium*, pathogenic only to the fruit. The spores of this new fungus were typical of those of *F. solani*.

The following work shows these two fungi to be distinct races of *F. solani* f. *cucurbitae*. Accordingly, the newly isolated fungus is hereinafter designated as race 2, and the well-known root-, stem-, and fruit-rotting pathogen as race 1.

Pathogenecity to seedlings.—Seedlings of ornamental gourd (*C. pepo* v. *ovifera* Alef.) grown in sterilized soil were inoculated separately with spore suspensions of race 1, race 2, and a saprophytic clone of *F. solani* isolated from a source other than cucurbits. Only the seedlings inoculated with race 1 developed disease symptoms. The experiment was repeated, omitting the saprophytic *F. solani* and using seedlings of cucumber (*Cucumis sativus* L.), cantaloupe (*Cucumis melo* v. *cantalupensis* Naud.), watermelon (*Citrullus vulgaris* Schrad.), pumpkin (*Cucurbita pepo* L.), White Bush Scallop, and Ornamental gourd. In all cases symptoms appeared only on the plants inoculated with race 1 (Fig. 1). These tests determined that race 2 is not pathogenic to cucurbit seedlings.

In inoculation studies with race 1 on Zucchini squash (*C. pepo*) the rapidity and severity of seedling invasion was increased by increasing the spore load in the suspension, and vice versa. With the above method of inoculation symptoms usually appeared in 4–14 days, depending on amount of inoculum, age of the plants, variety of cucurbit used, and growing conditions. Cucumber seedlings occasionally took 3 weeks or more to show good symptoms.

When root rot of seedlings was the result of contaminated seed, lesions containing the fungus were occasionally found on the cotyledonary or even the first set of primary leaves or upon the petiole or aboveground stem. In general, however, the rot, which primarily involves the cortical tissue, advances only a short dis-

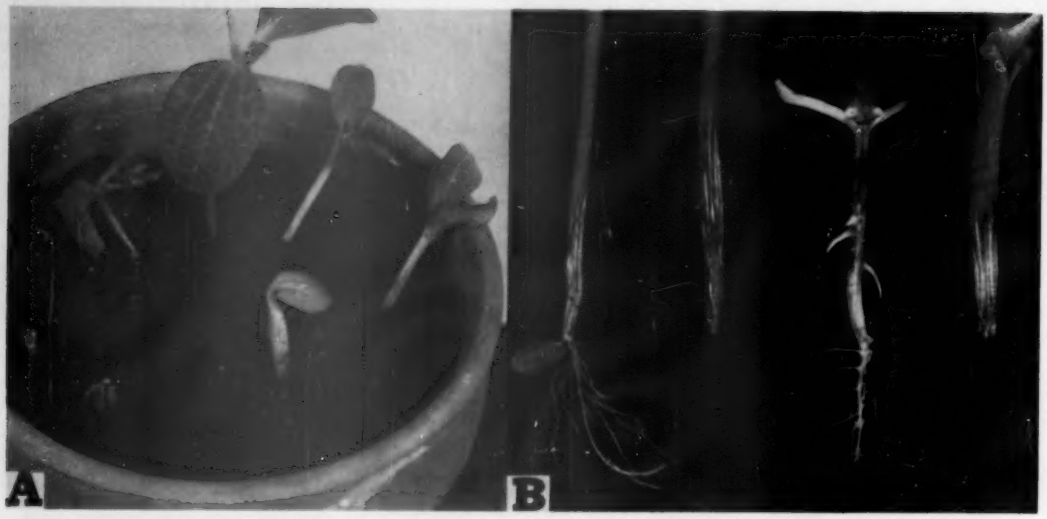

Fig. 1.—**A)** Damping-off of cucurbit seedlings by *F. solani* f. *cucurbitae* race 1. **B)** Seedlings attacked by race 1 showing typical linear coalescing cortical lesions of the hypocotyl. *F. solani* f. *cucurbitae* race 2 attacks not the growing plant but only the maturing fruit.

tance aboveground; a similar observation was made by Conroy (4). At first the rot is in the form of streaks parallel to the axis of the plant. In other words, the cortical decay spreads much more rapidly parallel to the stem than around the stem. Progress is rapid. Entrance of the fungus into the vascular system and extensive development therein may follow the more typical decay of the cortical tissues, but the disease is typically a cortical rot. This disease is therefore not to be confused with the vascular wilts of cucurbits caused by forms of *Fusarium oxysporum*.

Nearly 100 varieties of squash and pumpkin and more than 60 varieties of watermelon, muskmelon, and cucumber have been tested in the greenhouse for susceptibility to race 1. None of the varieties tested proved to be highly resistant, perhaps because the conditions of the tests were more favorable to the disease than may ordinarily occur in nature, particularly as regards the amount of inoculum. In addition, different samples of the same variety obtained from different commercial sources did not always give the same reading of relative susceptibility. Nevertheless the disease has not yet been observed in the field in such varieties of squash and pumpkin as Blue Hubbard squash, Golden Delicious squash, Mammoth Golden Cushaw, Large Cheese pumpkin, and others found to be relatively resistant in the pathogenicity tests. Likewise, cucumbers as a class appeared to be relatively resistant in the greenhouse tests and would not be expected to be seriously affected under natural conditions. The disease has occasionally been severe on greenhouse-grown cucumbers in central California, however. Watermelons and muskmelons were found to be susceptible in the tests, but only the Honeydew has been found by the authors to be attacked under natural conditions. Kendrick et al (10) found the disease on cantaloupes in the field in Los Angeles County and the Imperial Valley.

Pathogenicity to fruit.—Fruit of pumpkin, watermelon, cantaloupe, and Italian Edible gourd (*Lagenaria* sp.) were inoculated in the laboratory in replicate with race 1, race 2, and the saprophytic *F. solani*. Both race 1 and race 2 produced lesions within 20 days, and the fungi were recovered from the diseased tissue. The saprophyte caused no lesions. The lesions caused by the 2 races were similar, and the symptoms produced by each race developed in the same manner as those observed in the field (Fig. 2). Under moist conditions, race 1 forms areas of grayish-white spore masses, whereas race 2 tends to be somewhat buff-colored. Race 2 invades immature or young fruit more slowly than race 1, and therefore is a parasite primarily of mature cucurbit fruit.

To compare pathogenicity on mature fruits, spore suspensions of race 1, race 2, and the saprophytic clone of *F. solani* were prepared. The density of the spore concentration was made about equal by visual inspection, and the suspensions were poured separately into sterilized soil in pots, 4 pots for each isolate. The soil in each pot was removed, mixed thoroughly to obtain even distribution of the inoculum, and repotted 48 hours later, and fruits of ornamental gourd and White Bush Scallop squash were placed on the soil. After 14 days, the fruits were removed and examined. Both race 1 and race 2 produced lesions, and the pathogens were re-isolated and identified. The saprophytic clone of *F. solani* produced no lesions.

When the cucurbit *Fusaria* are followed by secondary invaders, the symptoms can be similar to those described by Gries (7) and Conroy (3, 4). Typically,

however, the fruit rot induced by the *Fusaria* that is discussed here is of a firm, dry type, and this becomes especially apparent after the fruit rind has begun to harden. A softer rot is obtained with young fruits or those having softer rinds, but even there it may be classified most appropriately as dry rot.

The rot may begin at one or several points on the fruit, as more or less circular spots that continue to enlarge and may coalesce. The rate of development of these lesions depends on the environment and the plant variety. The rot of mature fruit is not a rapid breakdown of tissue in the sense that *Rhizopus* rot is. Necrotic spots frequently exhibit a zonation, which on certain varieties becomes pronounced. In the absence of free water the surface lesions may increase slowly and fruit lesions may show no appreciable enlargement for a week or more. Yet the *Fusarium* pathogens may penetrate the rind quite early in the development of the spot and gain entrance to the seed cavity of the fruit (Fig. 2). There they grow rapidly, contaminating the seed, and external evidence of infection is for a while lacking except for the lesion at the point of entry.

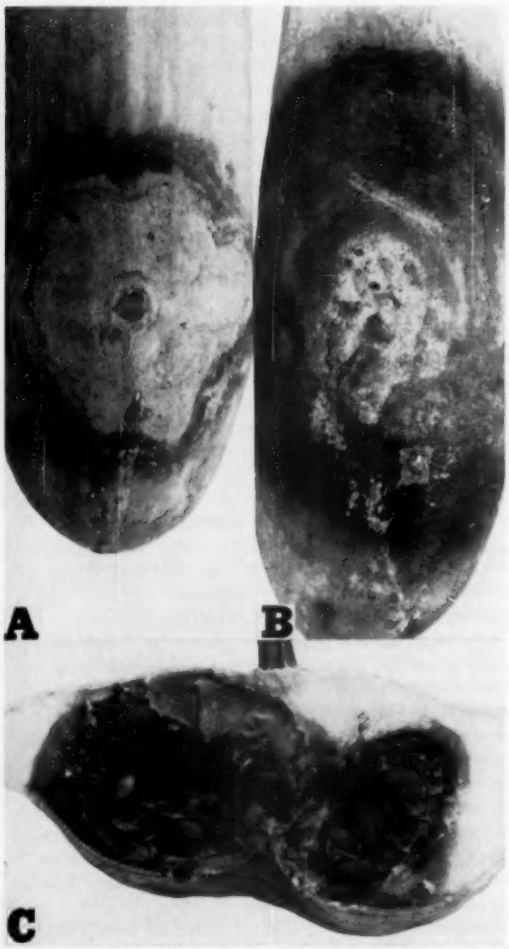

Fig. 2.—Symptoms on fruit. **A)** Field infection of Zucchini squash by *F. solani* f. *cucurbitae* race 1. **B)** Field infection of *Lagenaria* sp. by *F. solani* f. *cucurbitae* race 2. Both fungi invade the fruit from the soil and cause a similar firm, dry rot. **C)** Seed cavity of White Bush Scallop invaded in the field by race 1. The same development occurs with race 2 and leads, with both fungi, to an invasion of the seed coat generally without loss in viability of the seed.

In the field and with both races of the fungus, the fruit rot phase originates from direct primary infection from the outside, and the usual point of entry into the fruit is in the regions in contact with infested soil. For this reason the fruit rot may not be discovered unless the fruits on the ground are turned over. This becomes of special significance when a field grown for seed is inspected for the disease just before harvest. It sometimes happens that the root rot phase caused by race 1 is not conspicuous on land that contains the fungus in low initial concentrations at the time of planting. In some instances, however, a number of fruits may have become infected where they touch the infested soil. These infections will be overlooked unless the fruits are turned over, and may result in high percentages of seed invasion.

These remarks are particularly important with respect to race 2, which attacks the fruits only.

Seed transmission.—The following experiments were made because it was not unusual to observe nearly 100% seed transmission of both races of the fungus from badly infested commercial plantings of squash and of gourd. To sterilized soil in pots were added spore suspensions of race 1, of race 2, of a mixture of both races, and of a mixture of both races together with a saprophytic *F. solani* obtained from a source other than cucurbits. The soil in all the pots was removed, thoroughly mixed to obtain even distribution of the inoculum in the soil, and repotted. At this time, fruits of ornamental gourd containing mature seeds were placed on the soil surface in all the pots. One month later 40 seeds, selected at random, were removed from each fruit, surface-sterilized in a 10% solution of Clorox, and plated out on PDA. This experiment, repeated with similar results, showed that both races invade the seed; that, with both present, race 2 invaded the fruit and seed more rapidly than race 1; and that, once in the seed, race 2 in some manner prevented early establishment of race 1 within that seed. A similar phenomenon was not noticed in the case of seedlings. Such seedlings were attacked just as rapidly when both fungi were present as when only race 1 was present. The saprophytic *F. solani* was not recovered from the seeds. In the case of race 1 and of race 2 the mycelium is found in a layer between the seed coat and the cotyledons. Normally the cotyledons do not seem to be invaded and the germinability of the seed remains generally unaffected.

Since both race 1 and race 2 penetrate the seed coat they are beyond the reach of surface disinfestants. Gries (7) found that application of a 1:1000 dilution

of $HgCl_2$ for 15 minutes controlled only surface contamination of the seed and had no effect on the mycelium of race 1 within or beneath the seed coat. Similar results obtained by the present authors with both races provide additional evidence for their internal invasion of the seed.

Control.—As mentioned previously, the distribution of race 1 is world-wide. Race 2 has been isolated from cucurbits grown in southern and central California, one specimen was received from Ohio. Race 2 is prevalent in Stanislaus county on cucurbits grown for seed, particularly in fields of Italian Edible gourd and Ornamental gourd. Sample lots of such seed obtained from a commercial source had up to 45% infection of race 2.

Though race 2 has been found to be pathogenic to watermelon and cantaloupe fruits in the laboratory, it has not been found attacking these fruits in the field. Likewise, as previously indicated, most muskmelon and watermelon seedlings have been found to be susceptible to race 1 in greenhouse tests yet the only muskmelons found attacked under natural conditions have been the Honeydew melons and cantaloupes.

The reasons for the restriction of the disease on these crops in the field is unknown. It may be due to the fact that the cucurbit pathogens are not commonly seed-borne in muskmelons and watermelons, either because secondary organisms rapidly invade the succulent tissues and overwhelm the pathogens or because such completely rotten fruit are never harvested for seed. Regardless of the reason, these crops can be susceptible in the field to both races of the fungus. Dr. John T. Middleton, in reports and in correspondence with the authors, has conclusively demonstrated the presence of root and stem rot caused by race 1 on cantaloupes in production fields in southern California. He further showed that these disease incidences occurred where cantaloupes had followed diseased plantings of squash. In one particular instance he reported that stem rot affected 25% of the cantaloupes in a commercial field that had been planted to squash for 3 consecutive years. Dr. Middleton obtained no evidence that these outbreaks originated from infested cantaloupe seed, but rather that they originated from the soil infested with race 1 through the previous plantings of infested squash seed. These observations were confirmed by the authors in that the fungus was not observed in the major cantaloupe seed-producing areas of California.

It is apparent, then, that muskmelons are susceptible to race 1 and to race 2 and that care should be taken not to plant these crops in soils infested with cucurbit *Fusaria*. The same can hold true for watermelons. The incidence of the disease on cucurbit fruit seems to be correlated with the amount of moisture present, especially at the soil surface. Early rains in the fall or irrigation late in the season increase the severity of fruit rot, as will any other condition that keeps the surface of the soil wet or prevents soil moisture evaporation, such as an abundance of weeds. Furthermore, the fruits become more susceptible to race 2 as they mature. All of these factors combine to explain the prevalence of the disease on cucurbits grown for seed, which are harvested late in the fall.

Since the pathogens are carried over from season to season in both soil and seed, disease prevention depends primarily on avoiding infested land and using disease-free seed. The latter is of particular importance since dissemination of the disease to new land or into new regions is chiefly through infected seed. Disease-free seed may be obtained from an infested field if only sound, uninfected fruit are harvested.

Tyner (16) reported some benefit from seed treatment with 2% Ceresan when planting was in soil infested with race 1. Tests with seed treatment in California on seed from fruit infected with race 1 showed that the mercuric chloride treatment materially reduced the disease, indicating that most of the infection was surface-borne. The results again showed, however, that this treatment cannot be depended on to eradicate the organism from internally infected seeds.

Ark and Dekker (1) and Dekker and Ark (5) obtained good control, in the laboratory, of squash seed internally infected with race 1 with a 24-hour soak in a 50-ppm solution of the antibiotic GS-1. They reported that the antibiotic was not phytotoxic at the concentration used.

Gries (7) had some success with a hot-water treatment in sterilizing internally infected seed but at the expense of an appreciable reduction in germination. He further suggested that the fungus may die out of the seed after 2 years of storage. Conroy (4), however, found that 2.6% of such viable seed gave rise to stem rot. Limited tests with race 1 in California also suggest that infected seed stocks may be cleaned up by aging. Such seeds were planted after storage in the laboratory for 6 years. Germination had fallen off considerably, but no infection was obtained in any of the more than 200 plants obtained. Before aging, these lots had shown 30–50% seedling infection.

Although surface treatment cannot be depended on to clean up the seed completely, a mercuric chloride soak is quite effective from a commercial standpoint because: 1) internally infected seeds have probably been weeded out in most instances by discarding the obviously rotted fruit at harvest or at the time of cleaning and washing the seeds, and 2) it does disinfest the surfaces of the seeds that become contaminated with spores of the fungi during threshing and washing. It has also been found that cucurbit-free rotation of 4 years generally reduces disease caused by race 1 to a level where it is not a problem.

Cucurbit seeds, generally, are free of both races 1 and 2 where the above control measures have been followed.

Comparison of the two races in culture.—When clones of races 1 and 2 were compared in culture, they were found to produce morphologically indistinguishable macroconidia and microconidia except that some microconidia of race 2 were larger and kidney-shaped.

This deviation was not constant, however, and most of the microconidia of race 2 were similar to those of race 1.

Numerous studies on race 1 have shown it to be an extremely variable organism. Prasad (11), in comparative studies of different clones of the fungus, found that pathogenicity varied greatly in the 33 strains studied. Similar studies, carried out with race 2, by Toussoun (15) showed that the variability within this organism was just as great, and of the same kind as that in race 1. Comparative studies made with strains of race 2 on mature fruit showed that pathogenicity varied greatly, but none of the clones proved to be pathogenic to seedlings.

Race 1 was shown by Snyder (12) to have an ascigerous stage in *Hypomyces*. Race 2 likewise has been found to have a similar perfect stage, though it produced only red perithecia, and not both red and white perithecia reported by Snyder for race 1 (13). The 2 races did not cross, however.

Both races are composed of individuals that are self-sterile inter-fertile hermaphrodites. In addition, unisexual males and females as well as neuters have been found in race 1 (8, 9), whereas only unisexual males have been found so far in race 2.

Both race 1 and race 2 will produce the perfect stage in culture under appropriate conditions, but perithecia of neither race have been found in nature to date. With race 1 this may be due to the fact that cucurbit fields infested with the organism have yielded only one compatibility type or the other. With race 2, in contrast, both compatibility types have been found in the same field, so the absence of perithecia is probably due to the environment. In culture, race 2 is not as amenable as race 1 to the production of its ascigerous stage.

The two races produce spores that are morphologically alike except for occasional large kidney-shaped microconidia in race 2. Both have a perfect stage in *Hypomyces*, and their perithecia are morphologically alike though the races do not cross with each other. Both organisms are seed-borne.

These similarities, allied to an extensive natural variation in each race, preclude any separation into species on a morphological basis. They are separated on the basis of their differences in pathogenicity on a subspecific level, and accordingly are designated separate races, as follows:

Hypomyces solani f. *cucurbitae* race *1*.
Pathogenic to the roots, stems, and fruits of cucurbit plants.

Hypomyces solani f. *cucurbitae* race *2*.
Pathogenic only to the fruits of cucurbits.

Discussion.—In the widespread, ubiquitous species, *Fusarium solani*, only about a half-dozen pathogenic forms are known, and these are highly specialized as to hosts. The forms on pea, *F. solani* f. *pisi*, and bean, *F. solani* f. *phaseoli*, are well-known examples of virulent, cortical invaders of growing plants, and they compare closely in virulence and behavior with race 1 of *F. solani* f. *cucurbitae*. The equally well-known potato tuber-rotting form, *F. solani* f. *radicicola* (syn. *F. coeruleum*), on the other hand, attacks the maturing potato tuber but not the stems or roots of the growing plant, and in this respect is more comparable to race 2 of *F. solani* f. *cucurbitae*. There is a form, designated *F. solani* f. *eumartii*, that attacks the growing plants of potato and the tubers too. In a sense, races 1 and 2 of the cucurbit fungus parallel, respectively, *F. solani* f. *eumartii* and *F. solani* f. *radicicola*. This suggests that these last-named two trinomials could be considered as 2 races of one potato-invading form. Such a step has not been taken, because the two diseases on potato have been thought distinctive enough to justify their retention. *F. solani* f. *batatis* is different from the foregoing formae in that it attacks the growing stem of the sweet potato plants only when the underground stem is injured.

Thus it is seen that some pathogens in *F. solani* may be very virulent and become major, well-established diseases of their hosts, whereas others are relatively mild and ordinarily of little importance. These two kinds of pathogenesis are represented by races 1 and 2, respectively, of *F. solani* f. *cucurbitae*.

One of the striking features of the races of *F. solani* f. *cucurbitae* is their seed-borne nature. It is not unusual for a badly infested seed crop of squash or of gourd to approach 100% seed transmission. Furthermore, these fungi readily invade the seed and lie dormant between the seed coat and cotyledons during storage. No other formae of *F. solani* are carried abundantly within the true seed.

A further unusual feature of *F. solani* f. *cucurbitae* race 2 is its disease cycle. It is carried internally in the seed without interfering with seed germination, and establishes itself in the soil without parasitizing the growing plant until fruit is maturing. Only then (providing the surface soil is moist) does the fungus initiate its pathogenic cycle by invading through the rind and subsequently through the seed coats, to complete the cycle and to rest again in the cavity of the seed of its host.

Whereas the pea and bean pathogens remain indefinitely in soil once they are introduced into a field, both races of the squash *Fusarium* seem to be relatively short-lived in soil. A cucurbit-free rotation of 4 years is generally sufficient to reduce the disease to a level where it is not a problem. It is this poor ability to survive in soil in high populations for long periods, coupled with the effectiveness of a 15-minute soak of infested seed in mercuric chloride, that makes it possible to bring the disease under control rather rapidly. Seedsmen who have had high percentages of the cucurbit *Fusarium* in certain lines of seed have been able to clean up these lines within a year or two by such treatment and by planting in disease-free soil. It may be the foregoing biological features of *F. solani* f. *cucurbitae* that have kept the diseases it causes from becoming the persistent and chronic economic problems of cucurbits that have the corresponding diseases of peas and beans.

Saprophytic strains of *F. solani* abound everywhere

and are aggressive in the decay of dead and dying plant tissues. Dr. George H. Godfrey (correspondence with the authors) reported that the species has been a dominant factor in the rotting of mature cantaloupe fruits in the field in Texas during wet weather. A clone of this Texas fungus has been examined and most nearly approaches race 2 in culture but does not produce the perfect stage and does not cross with race 2. Limited pathogenicity tests on ripe watermelon and cantaloupe fruits have shown the Texas fungus to be seed-borne on these hosts and to be more effective than race 2 in invading and rotting ripe cantaloupe fruits. Like race 2, it does not attack the growing plant. It is felt therefore that this fungus can be included in race 2, on a temporary basis at least, and until it is shown that its pathogenic specialization is great enough to warrant its placement in a third race of *F. solani f. cucurbitae*.—Department of Plant Pathology, University of California, Berkeley.

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UREDOSPORE PRODUCTION BY UROMYCES PHASEOLI

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SUMMARY

Under prevailing greenhouse conditions, uredospores of *Uromyces phaseoli* were first matured 7–8 days after inoculation of Pinto bean. Spore production was increased by free water or high humidity for limited periods. Passive liberation of spores began about 2 days after spore maturation. With 0.01–0.2 pustules per cm^2 of leaf area, the number of spores produced per pustule per day was about 400, 8 days after inoculation, 3000 at 9 days, 12,000 at 11 days, 40,000 at 15 days, and 70,000 at 21 days. Sores per pustule per day 15 days after inoculation were about 30,000 for 0.2–2 pustules per cm^2, 15,000 for 2–10 pustules, 4000 for 10–20 pustules, 500 for 20–50 pustules, and 200 for 50–150 pustules. Pustules opened sooner for infections of 10–100 pustules per cm^2 than for infections of 0.1–10 pustules per cm^2, and opened sooner on the upper than on lower leaf surfaces. Leaves with about 200 pustules per cm^2 were killed in about 10 days, leaves with about 100 pustules in about 12 days, with 50 pustules in about 16 days, and with 20 pustules in about 22 days, but these times were very variable in different trials. The potential production of uredospores was about 1 million per cm^2 for infections of 2–100 pustules per cm^2 but appears greater for lighter infections. The generation time of *Uromyces phaseoli* (the time for doubling the population of spores) was about 0.8 day.

Previous quantitative information on uredospore production by rusts seems limited. Number of spores per uredium is given as over 3000 by Bolley and Pritchard (1), as over 100,000 by Stakman (9), and as over 350,000 by Humphrey et al (6). Rate of uredospore production is given as 2000 per uredial pustule per day for about 2 weeks by Chester (4), as 1500–2000 per pustule per day by Cammack (2), and as 200,000 spores in 20 days by Gäumann et al (5).

Materials and methods.—Beans (*Phaseolus vulgaris* L. var. Pinto) were grown in 4-in. pots of sterilized compost soil in a greenhouse at about 18°C at night to 28°C in the day. Plants were inoculated at about 10 days from seeding by spraying a spore suspension on the lower surfaces of the primary leaves, and the plants were incubated overnight in a moist chamber. The infection dosage was varied by varying the concentration of spores in the inoculum. Pustule density was measured by counting the number of pustules per leaf or in representative 1-cm^2 areas. The area of leaves was calculated from the length times the width and divided by 1.35. The uredinial stage of bean rust (*Uromyces phaseoli* (Pers.) Wint. var. *typica* Arth.) was used throughout.

Growth of uredial pustules was determined by microscopic measurements with transmitted light. In many cases, especially with young infections, the leaves were

cleared with chloral hydrate and stained with acid fuchsin before microscopic examination, but in some cases the limits of the mycelium could be seen by transmitted light in living leaves.

When infected leaves were to be maintained for more than about 12 days after inoculation, the new plant growth beyond the primary leaves was removed.

Host injury was recorded by a decimal rating method in which 10 indicated that the leaf was fully turgid, and 0 that the leaf was dead, with intermediate values indicating intermediate degrees of injury. This is not as satisfactory as a quantitative weighing method (13) but is useful and practical when the condition of the same leaves is followed for several days.

To measure the effect of humidity on spore production, individual attached leaves were placed in closed chambers with water, while the opposite attached leaves were held in similar chambers over calcium chloride.

To determine passive natural release of spores, slides were placed under leaves of plants in a well-lighted laboratory and examined at intervals. Results of such observations are herein reported, and are basic for establishing the reliability of the generally used washing method, because the washing method is unreliable if spores are naturally released continuously or before the time of washing. Determination of spore production from naturally released spores is considered unreliable, however, because of the extreme variability of the results.

For most determinations of numbers of spores produced, plants were trimmed to 1 infected leaf per pot, and this leaf was washed with 0.1% Tween 60 and then with water. Twenty-four hours later the leaf was again washed with Tween 60 and with water. The spores for the 24-hour period were diluted to give about 10–100 spores per 0.01 ml (with experience this could be determined by inspection), and the numbers of spores in two or three 0.01-ml portions were counted microscopically. The total number of spores was calculated by the dilution factor, the number of spores per cm^2 was calculated by dividing the total number of spores by the leaf area in cm^2, and the number of spores per pustule was calculated by dividing by the number of pustules. For example, if a leaf with 25 pustules was washed and the spores suspended in 50 ml of suspension, and three 0.01-ml portions yielded 59, 80, and 63 spores, the number of spores per pustule was

$$\frac{\frac{59 + 80 + 63}{3} \times 50 \times 100}{25} = 13{,}450.$$

From determinations of spore production by the same leaf, on successive days, or at intervals of several days, curves of spore production per day were constructed, and by addition of the numbers of observed or interpolated spores produced per day, the cumulative number of spores was calculated per leaf, per cm^2, or per pustule.

Results.—*Opening of pustules.*—Pustules were usually first apparent to the unaided eye 4–5 days after inoculation. By 6 days the raising of the leaf epidermis could be seen, and by 7 days the first pustule had opened (broken through the epidermis of the leaf). Data on the opening of pustules 7–10 days after inoculation are given in Fig. 1. Pustules extended through the leaf but usually opened first on the upper leaf surface and opened sooner for heavy infections than for light infections. All pustules were usually open 11 days after inoculation.

Growth of pustules.—The average diameters of the mycelial area and sporulating area of pustules are given in Fig. 2. The mycelium had reached a diameter of about 0.3 mm in 4 days, 2 mm in 10 days, 3.6 mm in 20 days, 4.5 mm in 30 days, and 5.1 mm in 40 days. The spore-producing area was initially (11 days) about one third the diameter of the mycelial area, but as the pustules grew older the size of the sporulating area became a greater proportion of the area of the colony. The diameter of the mycelium and of the sporulating area of pustules decreased as the number of pustules per unit area increased. In one test at 11 days after inoculation, the sporulating area was 0.93 mm in diameter for 1 pustule per cm^2, 0.72 for 20 pustules per cm^2, and 0.35 for 100 pustules per cm^2. In one test at 39 days after inoculation the diameter of the sporulating area was 4.8 mm, only slightly less than the diameter of the mycelial area.

Longevity of leaves.—The rate of killing of bean leaves by rust was increased as the intensity of infection was increased, as leaf age at inoculation was reduced, as humidity during sporulation was increased, and as new growth was permitted to develop beyond the primary leaves. Sample data showing the effect of intensity of rust infection on longevity of leaves are given in Fig. 3. The rate of killing of leaves varied greatly in different trials and was more rapid in winter than in summer. For all trials the average longevity was about 65 days for uninfected leaves, 52 days for leaves with 0–1 pustule per cm^2, 46 days for 1–4 pustules per cm^2, 28 days for 4–16 pustules, 23 days for 16–64 pustules, and 20 days for 64–150 pustules. Ths slope of the curves of estimated vigor decreased as the intensity of infection increased. The shortest period for leaves to be killed by rust was 10 days after inoculation.

Spore production.—Undisturbed release of spores was followed in 6 trials, including 2 trials started at 9 days after inoculation, 1 at 11 days after inoculation, 1 at 12 days, and 2 at 15 days. In all trials the shortest time from removal of spores by washing of leaves until the first detection of naturally liberated spores on the slides was 26 hours for one trial started at 15 days after inoculation. In this trial no spores were found at 22 hours after washing the leaves. The longest time from washing leaves until the first detection of release of spores was 87 hours, and the average was 49 hours. Since slides were usually examined every 4–8 hours in the day period until the first spores were caught, the first deposit of spores would logically be several hours before the first detection

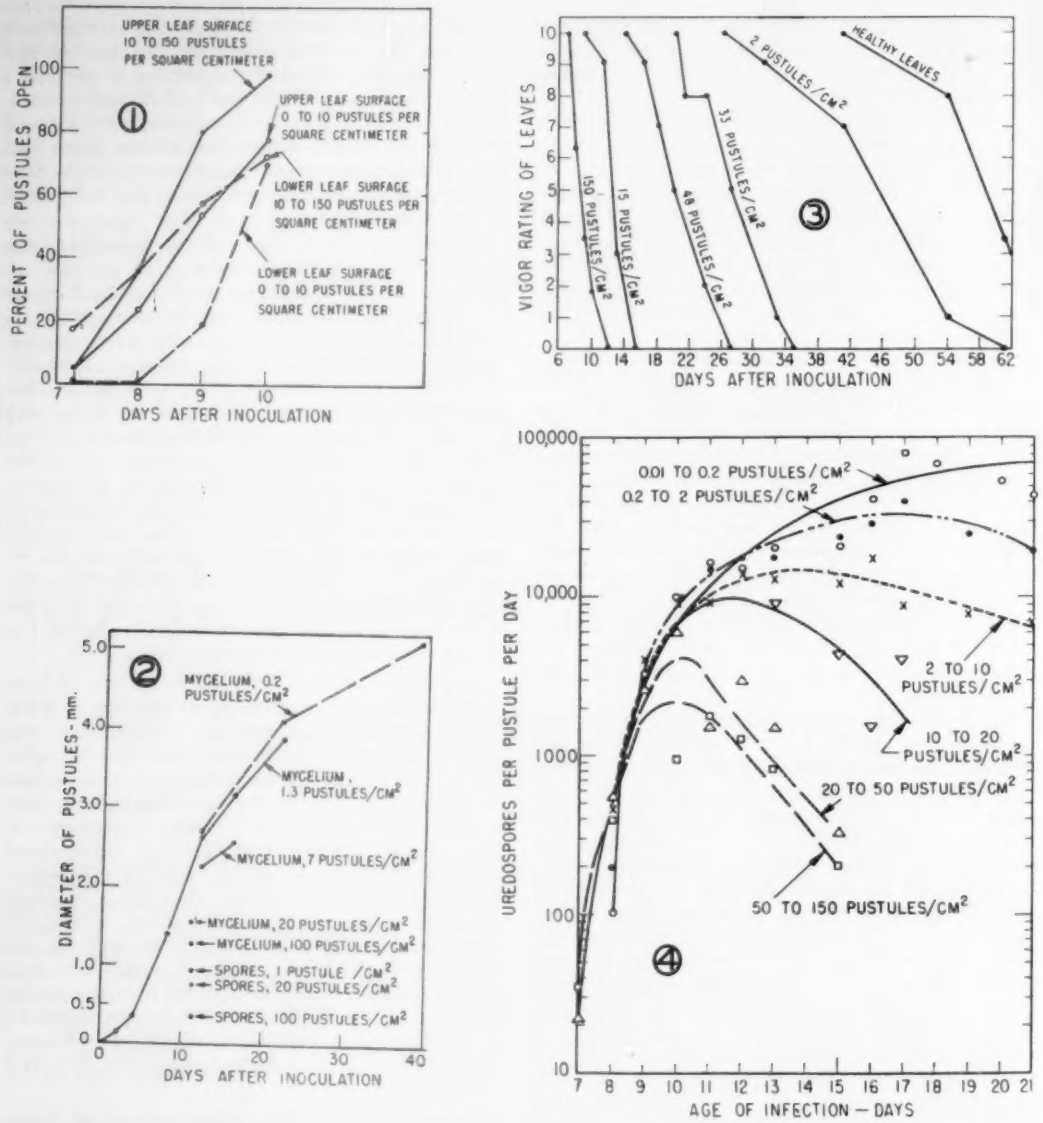

Fig. 1–4.—1) The effect of age of infection, intensity of infection, and surface of leaf, on opening of pustules of *Uromyces phaseoli* on bean. **2)** Growth of the mycelial area and the sporulating area of bean rust pustules. **3)** Relation of time and intensity of rust infection to killing of bean leaves. In the vigor rating, 10 indicates the leaves are of full vigor, 0 that they are dead, and intermediate values indicate varying degrees of intermediate vigor. **4)** Effect of age and intensity of infection on rate of spore production per pustule.

of spores. Undisturbed spores usually fell in groups; in one unusual case an estimated 4000 spores was deposited in one group. For 123 deposition areas comprising 5241 spores, 45 spores were found single, 38 spores were found in pairs, 324 in groups of 3–10 spores, and 4917 in groups of 11–4000 spores. It is expected that the single spores observed did not become detached from the leaf as such but became detached from larger groups during fall.

In one trial, spores collected after shaking infected plants over slides yielded 31 single spores, 30 spores in pairs, 63 in groups of 3 each, 93 in 15 groups of 4–10 spores, and 190 in 6 groups of 12–80 spores. Even this shows a greater tendency of spores to be liberated in groups than found in field collections.

The rate of spore production was calculated from 215 collections from washed leaves in 7 trials. The principal factors affecting rate of spore production

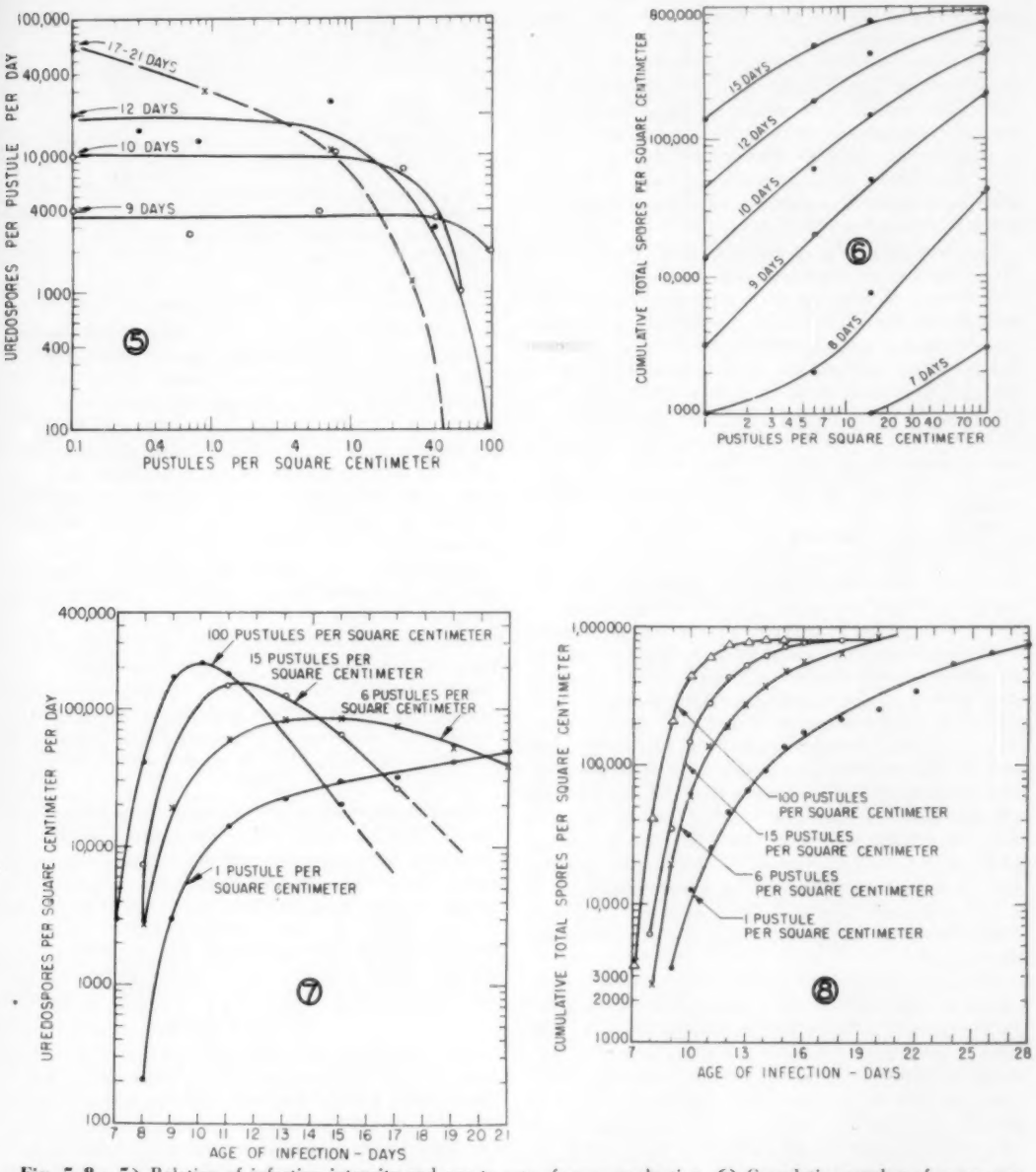

Fig. 5–8.—**5)** Relation of infection intensity and age to rate of spore production. **6)** Cumulative number of spores per cm^2 for different intensities of infection and for different ages of infection. **7)** Relation of age and intensity of infection to rate of spore production per unit area of leaves. **8)** Cumulative total number of spores per unit area of leaf for different intensities of infection.

were age of infection, intensity of infection, and humidity. The relations of age and intensity of infection were studied (Figs. 4–8), but not their relations with humidity.

For infections of 50–150 pustules per cm^2 (Fig. 4) spore production was about 20 spores per pustule per day for the 7th day, 400 for the 8th day, 1500 for the 9th day, 2100 for the 10th day, 1800 for the 11th day, 1200 for the 12th day, 800 for the 13th day, and 200 for the 15th day. The apparent production of spores after the leaf is dead (see Fig. 3) is probably an illusion resulting from maturation of spores on dying leaves. For infection intensities of 0.01 to 0.2 pustules per cm^2, no spores were caught on the 7th day, about 100 per pustules on the 8th day, and the number increased progressively with time, up to about 70,000

per pustules on the 21st day. Other infection intensities were intermediate.

When some of these data are plotted with intensity of infection on the abscissa and spores per pustule per day on the ordinate, the graphs in Fig. 5 result. The rate of spore production per pustule per day began to decrease at about 40 pustules per cm^2 at 9 days after inoculation, at 10 pustules per cm^2 at 10 days after inoculation, at 3 pustules at 12 days, and at 0.1 pustules per cm^2 at 17–21 days.

The cumulative total number of spores per unit area of leaves (Fig. 6) increased with time and increased with dosage, at least up to 15 days after inoculation, even though the rate of spore production per pustule was decreasing with increasing intensity of infection. For 1 pustule per cm^2 the cumulative total of spores per cm^2 was about 1000 at 8 days, 2500 at 9 days, 13,000 at 10 days, 45,000 at 12 days, and 130,000 at 15 days; whereas for 100 pustules per cm^2 the cumulative total was about 2500 at 7 days, 41,000 at 8 days, 210,000 at 9 days, 700,000 at 12 days, and 850,000 at 15 days.

The number of spores per cm^2 per day (Fig. 7) rises slowly and falls slowly for light infections and rises faster and falls faster for heavy infections. For 100 pustules per cm^2 the peak of spore production was at about 10 days, for 15 pustules per cm^2 about 12 days, for 6 pustules per cm^2 about 14 days, and for 1 pustule per cm^2 it was not reached at 21 days. In all cases the drop in rate of spore production was associated with loss of vigor of leaves (see Fig. 3).

The cumulative total number of spores per unit area of leaf (Fig. 8) is perhaps the best single criterion of efficiency of spore production. By this criterion all intensities of infection reached about the same value of 800,000 spores per cm^2, but this is reached much sooner for high intensities of infection than for low. It appears that for low intensities of infection of 1 and 6 pustules per cm^2 the cumulative totals are 1,000,000 spores or more, but this was not adequately determined.

Humidity effects.—The greater production of uredospores at high than at low humidities has been noted by Manners (7), Smith (8), and Yarwood (12). Data from a subsequent trial are given in Table 1. Overnight incubation in a moist chamber resulted in 30% open pustules on the upper leaf surface and 43% on the lower surface, in contrast to 5% open pustules on the upper surface and 22% on the lower surface for the leaves at low humidity. The greater percentage of open pustules on the lower than on the upper surface here is the reverse of the situation described earlier. On these leaves about 10 times as many spores were produced at high humidity as at low humidity. In two other tests there was a twofold increase in spore production from high humidity. This appears to be a greater increase from high humidity than previously reported.

Free water for only a short period increased the number of spores released. In one test uniformly infected leaves on 2 plants were exposed to a blast of dry air to dislodge many of the loose spores, and one leaf on each plant was sprayed with water without runoff at 7:30 A.M., 8:00 A.M., and 8:30 A.M. in a relatively dry greenhouse, whereas the opposite leaves were untreated. At 11:00 A.M. each leaf was assayed by washing to determine the numbers of loose spores present. Aliquots of the control leaves yielded 96 and 131 spores, whereas aliquots of the opposite wetted leaves yielded 277 and 331 spores, or the number of spores released was increased about twofold by wetting.

Table 1.—Effect of humidity on uredospore production by *Uromyces phaseoli*.

	Environment	
	Dry	Humid
% of pustules open at 9 days, upper leaf surface	1.2	
% of pustules open at 9 days, lower leaf surface	4.0	
% of pustules open at 10 days, upper leaf surface	5.0	30.0
% of pustules open at 10 days, lower leaf surface	22.0	43.0
Spores produced per pustule during 14 hours	78.0	770.0

Discussion.—This report is considered a contribution to our knowledge of the biotic potential of an obligate parasite.

The rate at which an organism may increase is a basic character limiting the rate of increase of any disease caused by this organism. Biotic potential may be given as generation time, which may be defined as the time for doubling of the population. This can be calculated as $\frac{T \log 2}{\log P_1 - \log P_0}$ where T is the time, P_0 is the initial population, and P_1 is the population after time T. For *Uromyces phaseoli* this can be calculated from the data given by making reasonable assumptions. If we assume that each spore is potentially germinable, the minimum generation time is calculated for the rate of 1 pustule per cm^2 at 10 days after inoculation (Fig. 8), for which the cumulative number of spores is about 12,000. The calculated generation time becomes $\frac{10 \times 0.301}{\log 12{,}000 - \log 1} = 0.74$ days. Other values calculated from the data presented would be between 0.74 and 1.3 days. These values are close to the value of 1 day calculated from the data of Chester (4), though the data presented here are much different from those presented by Chester. Actually with data of this type, a tenfold difference in numbers of spores produces less than a twofold difference in the generation time.

No disease increases in severity in nature at the same rate as the biotic potential of the pathogen, but some approach it more closely than others. Several examples of high rate of increase of disease are given by van der Plank (11) but the two greatest rates of increase or shortest generation times for a plant disease known to me are 3.1 days for *Puccinia rubigo-vera* (D.C.) Wint. as calculated from the data of Chester (3) and 2.3 days for *Puccinia graminis* Pers.

as calculated from the data of Underwood et al (10). It is believed that the uredial stages of the bean rust fungus and wheat stem rust fungus are sufficiently similar to be comparable for purposes of this study.

The calculated generation time of 1 day as an average value for increase of uredospores in this study, and of 2.3 days for increase in uredial pustules as calculated from data of Underwood et al (10), does not mean that spread of rust infection approaches 43% of the limit set by the generation time of the fungus. If we start with a single spore, the calculated number of spores after an arbitrary period of 30 days would be 2^{30}, whereas the calculated number of uredial pustules would be 2^{13} and the percentage of spores giving rise to pustules would be 0.00125.—Department of Plant Pathology, University of California, Berkeley.

NOTE: It is regretted that J. B. Powell's contribution "Oil inoculation of wheat with spores of *Puccinia graminis* var. *tritici*: Phytopathology 47:689-690, 1957," giving important information on the rate of increase of wheat stem rust, was missed in reviewing this subject.

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TRYPAN BLUE AND BOILING LACTOPHENOL FOR STAINING AND CLEARING BARLEY TISSUES INFECTED WITH USTILAGO NUDA

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Trypan blue effectively stains *Ustilago nuda* mycelium in barley embryos when added at 0.05–0.1% in the 5% NaOH used in extracting embryos from kernels. It may also be added at 0.01–0.05% to the lactophenol used for clearing tissue, although this method requires some destaining in clear lactophenol. Barley seedlings may be prepared for loose smut examination by boiling them in a 0.001–0.005% solution of trypan blue in lactophenol.

Introduction.—Lactophenol formulations for clearing and mounting fungi and other plant tissues were described by Linder in 1929 (2), Maneval in 1936 (3), and specifically for barley embryos and seedlings by Popp in 1951 (5). Morton (4) used boiling lactophenol as a quick means of both clearing embryos and darkening hyphae for barley loose smut determinations.

Trypan blue at 0.1–0.5% was reported by Boedijn in 1956 (1) to stain fungi quickly in 45% acetic acid and slowly in lactophenol. In 1958, Popp (6) showed that microtome sections of wheat embryos stained with 0.2% trypan blue in 45% lactic acid readily colored *Ustilago tritici* (Pers.) Rostr. mycelium for microscopic examination. Later that year, Popp (7) described the use of this stain with wheat and barley whole mounts for loose smut tests, and listed the several steps in the process. Embryos were cleared by heating 45 minutes at 5 lb pressure in 12% ethanol containing 15% NaOH, washing 15 minutes in several water changes, heating 1 minute at 5 lb pressure in a 3:1 mixture of ethanol and glacial acetic acid, and then heating 1 minute at 5 lb pressure in 45% acetic acid. Mycelium was stained by heating 1 minute at 5 lb pressure in 45% acetic acid containing 0.1% trypan blue, and excess dye was removed by heating 1 minute at 5 lb pressure in 45% lactic acid.

Fig. 1.—Whole mounts of treated embryos photographed through a dissecting microscope showing an uninfected embryo between 2 infected ones (about 10×).

These clearing and staining techniques have been combined and modified for use in barley embryo and seedling tests for detecting loose smut. Boiling lactophenol (1:1:1:5 lactic acid, phenol, glycerine, water) was found to be a fast, convenient method of clearing embryo and seedling tissues so that *Ustilago nuda* (Jens.) Rostr. mycelium is visible in infected material, and trypan blue was successful in staining the fungus without complicating the over-all process.

Procedures and results.—For embryo tests, material is prepared by the methods described in a previous paper (4), except that trypan blue is mixed with one of the liquids employed. The easiest procedure is to add the dye (0.05–0.1%) to the 5% NaOH used in

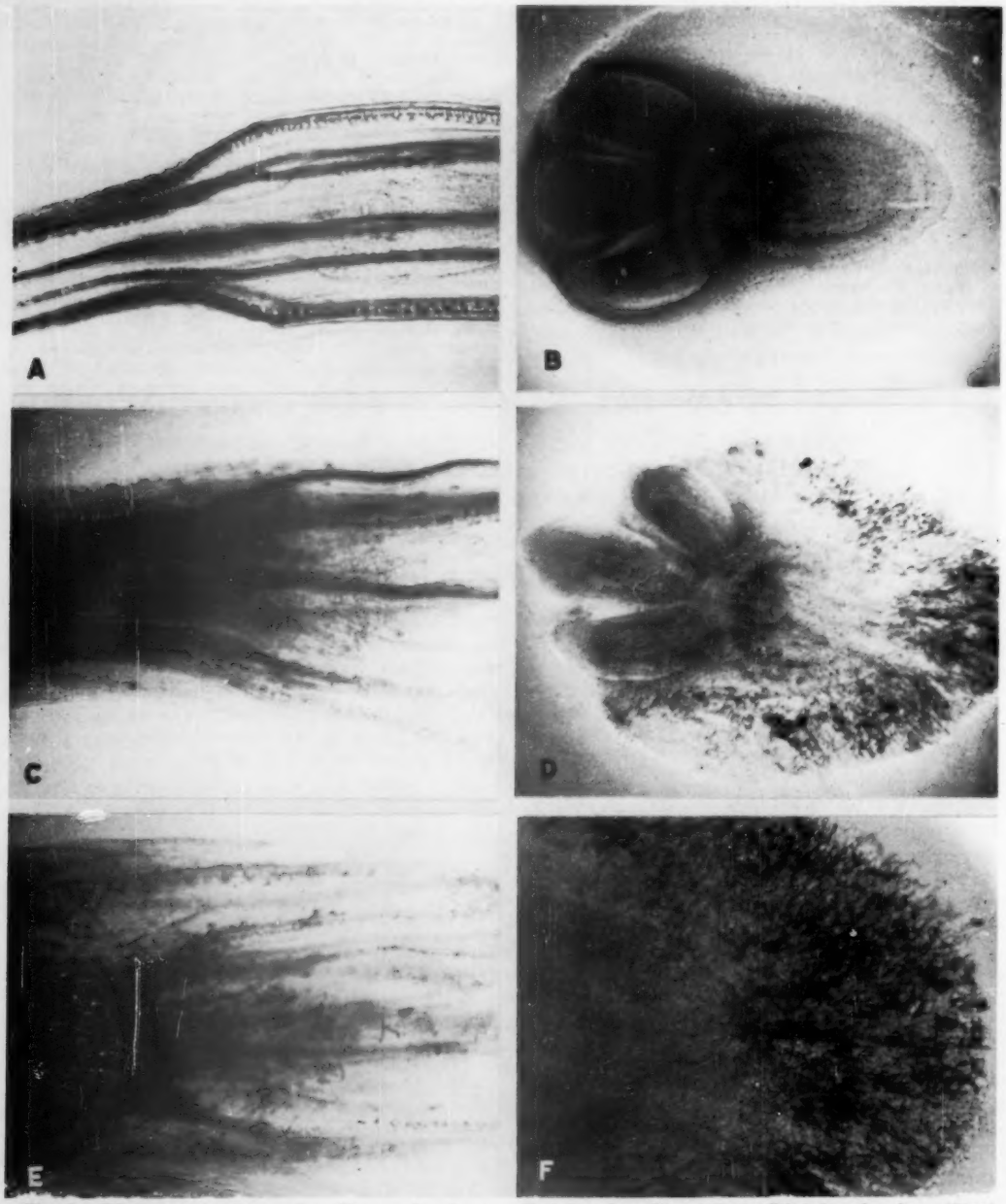

Fig. 2.—Whole mounts of treated seedlings and embryos photographed through a compound microscope: **A)** uninfected seedling (25×); **B)** uninfected embryo (20×); **C)** infected seedling (25×); **D)** infected embryo (20×); **E)** infected seedling (50×); **F)** infected embryo (60×). All magnifications are approximate.

extracting embryos from kernels. The embryos then may be processed in the usual manner, and infected specimens can be readily identified by bright blue mycelium (Fig. 1, 2). An alternate means is to add trypan blue (0.01–0.05%) to the lactophenol used in clearing the embryos, although this variation requires an extra boiling in clear lactophenol to remove excess stain.

Seedlings may be prepared by cutting out the third (crown) nodes of plants in the second-true-leaf stage, removing coleoptilar sheaths, and clearing for 15 minutes in boiling lactophenol. In this way, fungus hyphae are evident in infected nodes, and host tissues are exceptionally clear when specimens are mounted in glycerin and examined through a compound microscope. Coleoptilar sheaths may be removed mechanically by stripping off with needles, although this operation requires extensive time and concentration. The sheaths may also be slipped off over the basal ends of the plants, but this often results in a separation of tissue at the third node. It has been most feasible to remove sheaths by boiling nodes in 5% NaOH for about 20 minutes, loosening and partially macerating the outer tissues. The boiled material is poured into a white enamel pan, where nodes may be separated from sheaths with tweezers and placed directly into lactophenol. When sheaths are removed by this method, it is advantageous to mix 0.001–0.005% trypan blue in the lactophenol; infected seedlings then show bright blue fungus mycelium, and no destaining is required. In addition, it has been noticed that host tissues adjacent to infected areas also often stain blue, whereas uninfected material always remains colorless when dye is used at the proper concentrations. Examples of seedlings prepared in this manner are shown in Fig. 2.

Discussion.—The addition of trypan blue to the 5% NaOH used in extracting embryos for loose smut examinations has increased the distinctiveness of fungus hyphae so that even untrained technicians can detect infected material easily. The staining requires no additional steps in the over-all process, although excessive stain in the NaOH will make a longer clearing time necessary.

The clearing and staining of barley seedlings has proved to be important for detecting viable mycelium following various loose smut seed treatments, and makes it possible to evaluate such treatments much sooner and in far less space than when maturity tests are used. The boiling lactophenol clears the tissues so thoroughly that, in less critical tests, the sheaths do not have to be removed. In this variation, the cut tissue is left in 5% NaOH for at least 24 hours, and then cleared and stained as described above. Mycelium may be detected in infected plants, although details are partially obscured and light infections could possibly be missed.

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RELATIONSHIP BETWEEN TOMATO RINGSPOT AND PEACH YELLOW BUD MOSAIC VIRUSES

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SUMMARY

Plant-protection and serological tests showed that peach yellow bud mosaic, a virus that is soil-borne and has a nematode as a vector, is closely related to tomato ringspot, a virus with a wide natural host range and a mode of spread that was unknown.

Introduction and review of literature.—Tomato ringspot virus has been much studied, first by Price (15, 16) and later by Samson and Imle (17) and other workers. It occurs in many parts of eastern and central United States, but its mode of spread is unknown. Like tobacco ringspot virus, it has a wide natural host range, including gladiolus (1), hydrangea (3), tobacco (15), tomato (17), and soy bean (13), and is transmitted through the seeds of some of its hosts (15, 6, 11). Even so, tomato ringspot virus is serologically unrelated to (18) and possesses physical properties distinct from (12) tobacco ringspot virus.

Peach yellow bud mosaic, a soil-borne disease of peaches in California (20), is caused by a virus that is mechanically transmissible between peach and herbaceous hosts (21) and has a nematode, *Xiphinema americanum*, as a vector (2). The properties of this virus seem not to have been described. In peach, the symptoms resemble those caused by tomato black ring (7), a soil-borne virus that occurs widely in Britain and Continental Europe and is also thought to have a nematode vector (5). Plant protection tests gave no evidence of relationship between tomato black ring and peach yellow bud mosaic viruses (8), and

further tests made by the senior author with both peach yellow bud mosaic and tomato ringspot viruses showed that neither virus was related to any of the soil-borne ringspot viruses so far described from Britain and Continental Europe. Nevertheless the symptoms caused by the two North American viruses in a range of host plants were so strikingly similar as to suggest that the viruses themselves were related. Evidence substantiating this idea is reported here.

Materials and methods.—Peach yellow bud mosaic virus was cultured from infected peach seedlings sent from California by Dr. C. E. Yarwood. Two cultures of tomato ringspot virus were used. One, the Cornell isolate, supplied by Dr. K. M. Smith, Cambridge, originally came from the laboratory of Dr. A. F. Ross, Cornell University, Ithaca, where it appeared "spontaneously" in a tobacco plant; the other, the Wisconsin isolate, was supplied by Dr. R. W. Fulton, University of Wisconsin, from the American Type Culture Collection (AC-13). The culture of tobacco ringspot virus used was supplied by Dr. K. M. Smith. The viruses were transmitted by mechanical inoculation of sap and were propagated either in plants of French bean (*Phaseolus vulgaris* L. var. Prince), *Petunia hybrida* Vilm., or tobacco (*Nicotiana tabacum* L. var. Judy's Pride). Virus preparations were assayed for infectivity by rubbing them onto leaves of *Chenopodium amaranticolor* Coste & Reyn. and counting the numbers of local lesions that developed. Super-floss Celite powder (Johns Manville, Ltd.) was always mixed with the inocula to increase the numbers of infections. In the plant-protection tests, symptomless leaves of *P. hybrida* plants that had "recovered" from infection were inoculated with challenge viruses. Serological precipitation tests were mostly made by mixing 0.5 ml suitably diluted antiserum with 0.5 ml suitably diluted antigen in tubes, 8 mm in diameter, held at 34°C, and the amount of precipitation observed at intervals up to 5 hr. Control mixtures were always used with normal rabbit serum or saline in place of antiserum.

Results.—*Properties.*—All three virus isolates caused yellowish-bordered necrotic lesions and a systemic stunting disease in *C. amaranticolor;* small necrotic lesions and systemic necrosis in French bean; large necrotic lesions and systemic necrosis with "recovery" in *P. hybrida;* necrotic lesions and partially systemic ringspot symptoms in tobacco; and necrotic lesions and systemic chlorotic spotting in tomato (*Lycopersicum esculentum* Mill. var. Kondine Red). The isolates differed in the symptoms each caused in cucumber (*Cumumis sativus* L. var. Lockie's Perfection), *Datura stramonium* L., *Nicotiana glutinosa* L., and *N. rustica.* Tests made by inoculating sap to *P. hybrida* plants showed that each of these last 4 species became systemically infected by each of the virus isolates. The viruses reached high concentrations in newly systemically infected *P. hybrida* leaves, and tests made with sap from such leaves showed that all three virus isolates had similar properties. Infectivity was abolished when infective sap, diluted 1/5 with distilled water, was heated for 10 min. at 60°C but not at 58°C, or when diluted more than 10^{-4} with distilled water. Virus-containing saps lost little infectivity when kept at −10°C for 24 hr, but lost 80–90% in 5 days at this temperature.

Peach yellow bud mosaic and tomato ringspot viruses seem less stable than other viruses of the ringspot type, such as arabis mosaic and tomato blackring, for we found that infectivity was destroyed by most of the customary means of clarifying sap. Preparations made with the aid of butanol (19) sometimes retained half the infectivity of untreated infective sap, but when viewed in the electron microscope contained large amounts of debris and apparently disintegrated virus particles. Eventually, all serological tests were made with sap from infected *P. hybrida* leaves clarified first by heating for 10 min. in a water bath at 50°C and afterward centrifuging for 3 min. at 9000 G. The clear supernatant fluid was usually as infective as untreated sap, but sometimes precipitated spontaneously when incubated with saline at 34°C. The stability of such preparations seemed to depend on the age of the *P. hybrida* leaves used, and the best preparations were made from young, newly systemically infected leaves. Virus preparations that were stable for 6 hr or more when incubated with saline were made by centrifuging heat-clarified sap for 2 hr at 75,000 G, resuspending the resulting pellets in distilled water and clarifying the suspension by centrifuging for 3 min. at 9000 G. Such preparations contained large numbers of isometric particles of the order of 250 Å diameter, and of the shape characteristic for tomato ringspot virus described by Kahn et al (12). Similar preparations from healthy *P. hybrida* leaves contained no such particles.

Plant-protection and serological tests.—Plant protection tests in *P. hybrida* showed that each of the three isolates protected plants from infection by one another, suggesting that peach yellow bud mosaic and tomato ringspot viruses were related. By constrast, neither peach yellow bud mosaic virus nor the Cornell isolate of tomato ringspot virus protected *P. hybrida* plants from infection by tobacco ringspot virus. These results were confirmed by the serological tests reported below.

As there is no previous report of the preparation of an antiserum to peach yellow bud mosaic virus, and as other workers found difficulty in preparing one to tomato ringspot virus (18), the injection schedule used in our experiments is given in full (Table 1). The results (cols. 4, 5) show that the antibody titer rapidly increased from 1/16 to 1/256 when intramuscular injections were supplemented by intravenous injections.

Tests with the antiserum to peach yellow bud mosaic virus showed that it precipitated both the Cornell and the Wisconsin isolates of tomato ringspot virus as well as the homologous virus, and that the titer, 1/256, was the same to all three virus isolates. The antiserum also contained antibodies to normal *P. hybrida* proteins (titer 1/16). The precipitation end-points of clarified infective saps, determined with antiserm diluted 1/40,

Table 1.—Preparation of antiserum to peach yellow bud mosaic virus.

Type of injection	Virus preparation used[c]	Date of injection	Date of test bleed	Titer of antiserum
Intramuscular[a]	A	8.1.60		
	B	8.1.60	25.1.60	1/16
	C	20.2.60		
Intravenous[b]	C	7.3.60	7.3.60	1/16
	C	8.3.60		
	C	9.3.60		
	C	11.3.60	23.3.60	1/256
			2.4.60	1/256

[a] Each injection was 3–4 ml virus preparation emulsified with an equal vol. Freund adjuvant.

[b] Each injection was about 2 ml virus preparation.

[c] Preparation A: fresh sap from infected *P. hybrida* leaves clarified by centrifuging 10 min. at 9000 G. Preparation B: Preparation A concentrated 5-fold by ultracentrifugation for 2 hr at 75,000 G. Preparation C: partially purified by ultracentrifugation from infective sap clarified by means of butanol, concentrated 10-fold, and diluted 1/5 with saline.

varied from 1/8 to 1/64. As these results showed that peach yellow bud mosaic and tomato ringspot viruses were closely related, cross-absorption tests were made to estimate the proportion of common antigens. Absorption of the antiserum with 7 vol. of a preparation of the Cornell isolate (end-point 1/16) decreased the titer to this and to the other two isolates from 1/256 to 1/64. When the antiserum was absorbed with 7 vol. of a preparation of the Wisconsin isolate (end-point 1/64) no antibodies to this or to the other two isolates were detected with certainty. The lowest dilution of antiserum tested was 1/8, and the virus preparations were used diluted near to their endpoints. The results of both tests show that the three virus isolates share a high proportion of antigens. The antiserum did not react with highly infective preparations of tobacco ringspot virus.

Discussion.—The results of the plant-protection and serological tests agree in showing that peach yellow bud mosaic virus is closely related to and should be regarded as synonymous with tomato ringspot virus. They are evidence for a further example of a virus, whose mode of spread was unknown, being soil-borne. Like other soil-borne ringspot viruses described from Europe, tomato ringspot virus infects a wide range of herbaceous and woody plants; it is widely distributed in North America, has a nematode vector, *Xiphinema americanum*, and is seed-borne, a property that may be characteristic of some kinds of soil-borne viruses (14). Assuming that the two isolates of tomato ringspot virus were native of eastern United States, the lack of antigenic difference between them and the Californian isolate parellels that found among strains of arabis mosaic virus (4), which also has a species of *Xiphinema* as a vector (10(9). This contrasts with the high degree of geographical variation characteristic of raspberry ringspot and tomato black ring, soil-borne viruses thought to be transmitted by nematodes of another genus.

Although we, like other workers, detected no relationship between tomato ringspot and tobacco ringspot viruses, the latter shares so many physical and biological properties with other soil-borne viruses of the ringspot type as to suggest strongly that it too is soil-borne.

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IN VITRO NUTRITION OF THE TOMATO BACTERIAL SPOT ORGANISM

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SUMMARY

The bacterial spot organism (*Xanthomonas vessicatoria*) did not grow on medium in which nitrogen was supplied as nitrate, and grew very sparsely when N was supplied as ammonium salt. B vitamin supplements to those media did not affect growth. Cu, Fe, Mn, and Zn inhibited growth, and Ca was slightly stimulatory. None of 17 amino acids and/or amides supported good growth when supplied individually. When added collectively in the approximate proportions found in casein hydrolysate, together with thiamine hydrochloride and Ca, they supported luxuriant growth comparable to that with casein hydrolysate, yeast extract, or potato extract. A lack or disproportionate amount of any one of the amino acids and/or amides reduced growth of the bacterium.

The nutritional requirements of phytopathogenic bacteria are of considerable interest in that the host plant must provide all the nutrients necessary to a pathogen during infection and subsequent development. The present article deals with the nutritional requirements of *Xanthomonas vesicatoria* (Doidge) Dowson, the causal agent of the bacterial spot of tomato.

Materials and methods.—Pyrex glassware was rinsed in 0.4*N* HCl and in double-distilled water. Double-distilled water was used for preparing media and stock solutions of nutrients. The organism used was isolate 0-2894, secured from the State Plant Board of Florida. The bacterium was grown 12 hours on potato-dextrose agar slants, washed into sterile, distilled water, and diluted to an optical density of about 0.005–0.01 as measured at 620 mμ on a Lumetron colorimeter with a red filter. Portions of 25 ml of the medium in 125-ml flasks were autoclaved 15 minutes at 15 lb pressure. Each flask was seeded with 1 ml of the bacterial suspension. The inoculated flasks were placed for 36 hours on a continuous shaker at 110 single strokes per minute at 28°C (11). Growth of the bacterium was determined by measuring optical density.

The basal synthetic medium contained 0.2% KH_2PO_4, 0.02% $MgSO_4 \cdot 7H_2O$, and 1% sucrose. Other inorganic elements were added to the medium as stated. These were calcium as $CaCl_2 \cdot 2H_2O$, copper as $CuCl_2 \cdot H_2O$, iron as $FeSO_4 \cdot 7H_2O$, manganese as $MnSO_4 \cdot H_2O$, and zinc as $ZnSO_4 \cdot 7H_2O$. Only analytical reagent grade salts were used. Where 0.2% $NaNO_3$ or 0.2% NH_4Cl was the nitrogen source in the medium it is, for convenience, referred to as the nitrate medium or ammonium medium. Otherwise, specific nitrogen sources are indicated. The pH of the medium was adjusted to 6.8 before being autoclaved. Autoclaving never changed the pH more than 0.05–0.1.

Results.—The nitrate medium supported no bacterial growth. Addition of B vitamins (Thiamine hydrochloride, riboflavin, pantothenic acid, pyridoxine, nicotinic acid, and inositol) had no influence on bacterial growth. Doidge (1) reported that the bacterium may show feeble nitrate reduction on prolonged incubation. The ammonium medium supported meager growth of the bacterium and growth was not influenced by B vitamin supplements.

Bacteriological media generally include the elements Ca, Cu, Fe, Mn, and Zn (8, 9, 10). Early in this work, however, the elements Cu, Fe, Mn, and Zn were noted to inhibit the bacterium in ammonium medium. It is seen from Table 1 that these 4 elements decisively inhibited growth at a concentration of 1 μg/100 ml medium, which is much lower than that usually recommended. Ca appeared slightly stimulatory even at 10μg/100 ml. Addition of Difco bacto-yeast extract to the ammonium medium containing the 5 mineral elements not only reversed the inhibition but markedly stimulated growth. Analysis of the yeast extract preparation provided by the manufacturer showed 7.8 ppm Mn, 88 ppm Zn, and 19 ppm Cu. Since B vitamin supplement to the ammonium or nitrate media had no effect on growth, the amino nitrogen in the yeast extract may have been the growth-promoting factor.

To test the influence of amino nitrogen on the growth of the bacterium, casein hydrolysate, claimed by the manufacturer to be free of vitamins and salts, was chosen as a standard for comparison. Of the 17 amino compounds tested, each at 100 μg N/ml of medium, arginine, leucine, and methionine supported growth no better than the ammonium medium, whereas with asparagine and aspartic acid growth was only slightly better. Lysine, phenylalanine, serine, tryptophan, and valine supported meager growth. Since glutamic acid and glutamine were the only compounds that supported more than meager growth, they were tested at concentrations the same as or higher than NH_4Cl, asparagine, potato extract, yeast extract, and casein hydrolysate. As shown in Table 2, the last 3 of these supported luxuriant growth and strong pigment production, whereas growth with gluatamine and glutamic acid was intermediate between these and asparagine.

Since individual amino acids or amides were inferior to casein hydrolysate in support of bacterial growth, a combination ot amino acids was tested in the proportions found in casein hydrolysate. Based on analyses provided by the manufacturer, casein hydrolysate at 0.1% contained 10 mg amino-nitrogen per 100 ml and traces of B vitamins of which thiamine, riboflavin, and niacin occurred at 0.12, 0.11, and 0.20 μg/g, respectively. The mixture used, which contained arginine, lysine, tyrosine, tryptophan, phenylalanine, cystine, methionine, threonine, serine, leucine,

Table 1.—Influence of inorganic elements on growth of *Xanthomonas vesicatoria* when added to a basal medium.[a]

Element added	μg/100 ml medium	Optical densities[b] in experiment indicated 1	2	3	4	Av. optical density
None		.074	.030	.023	.027	.038
Ca	10	.082		.020	.045	.049
Cu	1		.013	.010	.011	.011
Fe	1		.019	.015	.019	.018
Mn	1		.018	.012	.018	.016
Zn	1		.016	.019	.014	.016
[c]		.007			.026	.016
[d]			.990	.900		.945

[a] The basal medium contained 0.2% KH_2PO_4, 0.02% $MgSO_4 \cdot 7H_2O$, 0.2% NH_4Cl, and 1% sucrose.
[b] Each value is the average of optical density readings at 36 hours of 4 replicate flasks for each treatment in each experiment.
[c] Ca was added at 10 μg/100 ml, and Cu, Fe, Mn, and Zn at 1 μg each.
[d] The same elements and rates as in footnote c plus 0.1% yeast extract.

Table 2.—Influence of certain amino acids and amides on growth of *Xanthomonas vesicatoria* in comparison with ammonium chloride, yeast extract, potato extract, and casein hydrolysate when added to a basal medium.[a]

Additive	Rate	Optical density[b]
NH_4Cl	0.2%	.025
L-asparagine	200 μg N/ml	.039
glutamine	200 μg N/ml	.409
D-glutamic acid	100 μg N/ml	.107
D-glutamic acid	200 μg N/ml	.156
D-glutamic acid	300 μg N/ml	.206
D-glutamic acid	500 μg N/ml	.281
NH_4Cl + yeast extract	0.1%	.950
Casein hydrolysate	0.1%	.785
Casein hydrolysate	0.5%	.967
Potato extract + 1% sucrose[c]		.730

[a] The basal medium contained 0.2% KH_2PO_4, 0.02% $MgSO_4 \cdot 7H_2O$, and 1% sucrose.
[b] Each value is the average of optical density readings at 36 hours of 4 replicate flasks in each of 2 experiments.
[c] Basal medium not added in this treatment.

isoleucine, valine, glutamic acid, aspartic acid, glycine, alanine, and proline, had about 10 mg amino nitrogen/100 ml basal medium. The 3 B vitamins and Ca were tested alone and in combination as supplement to the amino acid mixture. Table 3 shows the results. Thiamine and probably Ca increased the growth of the bacterium in the amino acid mixture.

Tests were then conducted to narrow down the number of amino acids required for luxuriant growth of the bacterium. Table 4 presents some of the results. It is suggested that inhibitory or antagonistic influences may occur among the amino acids, glutamic acid, aspartic acid, alanine, and serine.

Discussion.—Lewis (4, 5) emphasized that the availability in a host of particular nutrients like amino acids, organic acids, and vitamins governed successful host-parasite interaction. Garber (2, 3) considered 2 nutritional factors: the availability or unavailability of suitable nutrients in host tissues and the inhibitory effect of other compounds in the host.

It is indicated in the foregoing results that the bacterial spot organism may require a "balance" of 17 amino acids, thiamine, and probably Ca. Growth is retarded by any disturbance in the proportion or omission of 1 or more amino acids from the mixture. According to Snell (8), nutrients may be classified as essential, stimulatory, inhibitory, and apparent. Stimulatory and apparent nutrients are not essential

Table 3.—Influence of amino acids, vitamins, and calcium on growth of *Xanthomonas vesicatoria* in comparison with casein hydrolysate when added to a basal medium.[a]

Additive	Optical densities[b] in experiments 1	2	Av. optical density
0.1% casein hydrolysate	.80	.79	.795
Amino acid mixture[c]	.55	.58	.565
Amino acid mixture plus:			
R, T, N,[d] Ca, Fe	.63	.73	.680
N, Ca	.60	.63	.615
R, Ca	.61	.56	.585
T, Ca	.69	.67	.680
Ca	.53	.62	.575

[a] The basal medium contained 0.2% KH_2PO_4, 0.02% $MgSO_4 \cdot 7H_2O$, and 1% sucrose.
[b] Each value is the average of optical density readings at 36 hours of 4 replicate flasks for each treatment in each experiment.
[c] The amino acid mixture consisted of arginine, lysine, tyrosine, tryptophan, phenylalanine, cystine, methionine, threonine, serine, leucine, isoleucine, valine, glutamic acid, aspartic acid, glycine, alanine, and proline in the proportion they occur in casein hydrolysate.
[d] R = riboflavin, T = thiamine, N = niacin.

Table 4.—Influence of combinations of amino acids on growth of *Xanthomonas vesicatoria* when added to a basal medium.[a]

Amino acids added[c]	Optical densities[b] in experiment indicated 1	2	Av. optical density
Gl, ala	.280	.304	.292
Gl, asp	.090	.130	.110
Gl, asp, ala	.340	.290	.315
Gl, asp, ala, pro, gly	.320	.325	.322
Gl, asp, ser, ala	.080	.150	.115
Gl, asp, ser	.000	.000	.000

[a] The basal medium contained 0.2% KH_2PO_4, 0.02% $MgSO_4 \cdot 7H_2O$, and 1% sucrose.
[b] Each value is the average of optical density readings at 36 hours of 4 replicate flasks for each treatment in each experiment.
[c] Gl = glutamic acid, ala = alanine, asp = aspartic acid, pro = proline, gly = glycine, ser = serine, in the proportion present in casein hydrolysate but the concentration adjusted to give about 10 mg amino-nitrogen/100 ml medium.

but would support growth in one set of conditions or another. Lewis (4) defined "definitive nutrition" of a parasite as "that portion of the parasite's complex nutrition in terms of which it is possible to understand the outcome of the relationship between parasite and host," and includes both the promoting and inhibiting substances.

It is apparent from the results presented that at least glutamic acid, alanine, and thiamine are essential to the growth of the bacterium. The other amino acids may be considered stimulatory or inhibitory, according to Snell's terminology. Some possibilities may be considered in explanation of the fact that the other amino compounds that appear to be nonessential are nevertheless necessary if growth of the bacterium is to be luxuriant.

Alanine is known to be formed from pyruvate by transamination or by direct amination, and from aspartic acid by β-decarboxylation (7). Aspartic acid is a precursor of orotic acid, a pyrimidine precursor, though other amino acids may also contribute to pyrimidine synthesis. Glutamic acid is involved in transamination reactions, in conversions to proline and ornithine through glutamic acid-γ-semialdehyde, and in the formation of proteins. Metabolism of glycine involves conversion to purines, carbohydrates, and amino acids like serine and threonine. The reduced growth when aspartic acid and/or serine are added to the medium shown in Table 4 may be due to lack of the proper enzyme systems to utilize them by conversion to other compounds. Such a situation may allow survival of the bacterium without significant growth.

A second possibility for the suppression of bacterial growth by aspartic acid or serine may be due to prevention or inhibition of the uptake of the glutamic acid and alanine. Examples of competitive inhibition of uptake of amino acids are known (6). Valine is competitively inhibited by isoleucine in a valine-requiring mutant of *Escherichia coli*. L-aspartic acid inhibits growth of *Lactobacillus arabinosus* on L- or D-glutamic acid, but not on glutamine; the aspartic acid is assumed to prevent the penetration of the cell by L- and D-glutamic acid. Inhibition could also be due to competition for a specific transport site as in the inhibition of the growth of the serine-requiring putrefactive bacteria of sake by threonine. In all these cases the inhibition is between structurally related compounds only.

It is suggested from the work reported here that the bacterial spot organism needs certain amino acids in specific proportions in order to grow luxuriantly. It is pertinent, however, to ask the following questions. Is this balanced proportion of 17 amino compounds absolutely essential? Does the organism really have a limited capacity to synthesize various amino acids and to incorporate them subsequently into proteins? Is there a competitive inhibition among the various amino acids or are the reactions merely inhibited by metabolites? Could some of the amino acids be suitably substituted with analogs, keto acids, or growth factors so that the bacterium would thrive luxuriantly on a simpler synthetic medium? An extended study of the nutrition of the bacterium along these lines and analysis of the culture filtrates under various conditions of growth may provide answers to the questions raised. The same may also lead to the discovery of a suitable chemical or chemicals to serve as an antimetabolite and thus pave the way for chemotherapy. These questions will be discussed further in a paper on the development of bacterial spot in relation to various leaf constituents.—Department of Plant Pathology, University of Wisconsin, Madison.

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BOOK LISTING

Handbook of Toxicology.—*Dorothy S. Dittmer*, ed. 1959. Vol. V. Fungicides. W. B. Saunders Co., Philadelphia, Pennsylvania. 242 p. Price $5.00.

This handbook, prepared under the direction of the Committee on the Handbook of Biological Data, Division of Biology and Agriculture, National Academy of Science, contains information on 196 important fungicides. For the most part these compounds are listed according to the nomenclature of Chemical Abstracts, the alternative name or names being given both in the text and in the index. Information on these compounds is divided into the following categories: Molecular formula, structural formula, physical and chemical properties, fungitoxicity, toxicity to man and animal, uses, and precautions. In addition, 500 compounds that have fungicidal properties are listed together with their patent numbers and literature references. Plant pathologists will find this handbook a valuable source of information.

DAMPING-OFF ETIOLOGY ESPECIALLY IN FOREST NURSERIES

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Joint contribution from: Forest Biology Division, Research Branch, Department of Agriculture, Ottawa, (No. 635); Canada Agriculture Research Station, Saskatoon, (No. 42) (O. Vaartaja); and Forest Nursery Station, Indian Head, Saskatchewan, (No. 5) (W. H. Cram and G. A. Morgan).

SUMMARY

Inoculations of tree seedlings in aseptic test tubes with fungi showed great potential pathogenicity for many isolates of *Rhizoctonia solani* (mostly *Pellicularia praticola*), *Pythium debaryanum*, *P. ultimum*, *Phytophthora cactorum*, and several species of *Fusarium* and *Cylindrocarpon*. These comprised the most common isolates from diseased tree seedlings in several forest nurseries. Some less common isolates also demonstrated strong, moderate, or weak potential pathogenicity. Scots pine and caragana were inoculated with representative isolates in unsterilized soils. With light inoculum (culture suspension) the pathogenic effects of inocula were masked by those of natural soil floras. With heavy inoculum (infested seed-soil mixture), high mortality was caused by all 4 isolates, including *Thielaviopsis basicola*, which in laboratory tests was only moderate in potential pathogenicity and has no known association with damping-off. It is suggested that etiological studies on damping-off should be limited to tests of potential pathogenicity under aseptic conditions. The actual importance of isolates can be found through epidemiological and ecological approaches. Heavy artificial inoculations may perhaps be useful to simulate the most serious epidemics.

Mortality, mainly caused by naturally occurring *Pythium*, was increased by high soil moisture. The floras of loamy prairie soil types, including virgin sod, were pathogenic. Influences of temperature were variable and tended to be opposite in the two host species. Environmental effects were large with the natural floras and small with heavy inocula. *Fusarium* spp. were commonly isolated from healthy seedlings, mainly as harmless parasites or epiphytes. The partially discrepant results under sterile and unsterile conditions are thought to be caused by interactions of soil flora. Strong antagonism to the pathogens was demonstrated by bacteria, *Penicillium* spp., *Trichoderma viride*, and *Streptomyces* spp.

Problems in etiology of damping-off.—Pathogenicity is usually established by constant association and isolation of a parasite, reproduction of the disease by inoculation, and reisolation. Fulfilling just one or some of these requirements is not enough. Thus, *Fusarium* spp. were commonly associated with certain damping-off epidemics, but an inoculation experiment in unsterile soil indicated that the less common associates, *Rhizoctonia solani* Kühn and *Pythium* spp., were the important pathogens (43). Fusaria were associated even with healthy seedlings that would not have died. They either colonized dead tissues or failed to produce serious disease.

On the other hand, the association of many soil-borne pathogens with their hosts is difficult to establish. The association of *Phytophthora cinnamomi* Rands with little-leaf disease of pines was not known until Tucker's isolation technique, which utilizes apples as bait, was employed (7). Thousands of earlier isolations from roots and surrounding soil failed to yield the pathogen. In apple trees, *P. cactorum* (Leb. & Cohn) Schroet. colonizes only a narrow zone in living tissues because toxins from bacteria and decomposing bark kill it in dead tissues (6). For similar reasons *Phytophthora* spp., *Pythium* spp., and *Aphanomyces* spp., though common on roots of various diseased plants, are seldom isolated (9, 15). *Aphonomyces* spp. are also extremely sensitive to mercury compounds commonly used to eliminate the epiphytes usually present on plants taken from soil (17). Certain strains of *Phytophthora fragariae* Hickman are seldom isolated from roots, because they are closely followed by *Pythium* sp. and do not grow if dextrose is present in the medium or if the temperature is as high as is common in laboratory rooms (25). *Thielaviopsis basicola* (Berk. & Br.) Ferr. is difficult to isolate because of its slow growth and sensitivity to bacterial antagonism (18, 34); bait is often used in its isolation. Reisolation of such fungi in experiments may for this reason fail if the soil used is unsterilized.

One problem in experimental reproduction of damping-off is the vagueness and variation of the symptoms. For instances, *Pythium sp.* killed the seeds in sterilized media but in unsterile seedbed media (43) it mainly attacked seedlings. On the other hand, a certain damping-off symptom can be caused by fungi of different taxonomic groups. Furthermore, under aseptic conditions, damping-off can be produced by fungi that are seldom or never isolated from diseased seedlings, and by fungi that are usually considered as saprophytes (12, 43).

Damping-off of tree species.—Because of these problems the etiology of damping-off in many plants may be less well known than is commonly thought, and new approaches are needed in future studies. For instance, the importance is unknown of such predisposing factors as fertilizers (38), weeds (38), heat, drought, hail (39), excess water (45), and salinity (4).

In the following, the main attention is given to damping-off of tree species. This is a serious nursery problem, many species being highly susceptible over an extended period. The main published findings on this subject were recently reviewed briefly by Vaartaja and Cram (43). Species of *Rhizoctonia* and *Pythium* appear as very important causes of damping-off of trees, but further study is required of their importance in different environments and the role played by other fungi.

Koch's postulates were followed in a large number of tests in test tubes with various fungi and host species. In each tube, organisms other than tree seedlings and a fungus isolate were excluded. The results of such tests, as of any inoculation done in sterilized medium, should be considered to show only what may be called "potential pathogenity" of an isolate. (Many tests were made with *R. solani* and *Pythium* isolates by the senior author together with H. Saksena and P. Salisbury; details of these will be reported in other publications; the results generally agree with those reported here.)

Experiments were also made in the greenhouse in unsterile soils. These were alkaline soils, in which damping-off tends to be severe and persistent, especially on conifers. This common experience of nurserymen was recently confirmed by Schönhar (32).

Unsterile soils were used partly because the potential pathogenicity of an isolate does not indicate its actual importance in seedbeds, and partly because of the success of our earlier study (43). When tests with one type of inoculum were repeated in similar soils with similar hosts in the greenhouse, however, the results were widely varying in different years (mortality between 10 and 80%). To explore causes of such variation, the following factors were included in the experimental design: moisture, temperature, and modifications of soil types.

Isolations from nurseries.—The isolation methods and their results were largely reported earlier (38, 39, 43). Among thousands of fungus isolates obtained from tree seedlings in 5 forest nurseries in Manitoba and Saskatchewan, the following species were most frequent (in approximately descending order): *Fusarium oxysporum* Schlecht. emend. Snyd. & Hans.; F. solani (Appel & Wr.) Whet.; *F. acuminatum* Ell. & Ev.; *Pythium ultimum* Trow.; *P. debaryanum* Hesse; *Rhizoctonia solani* (mainly *Pellicularia praticola* (Kotila) Flentje but to some extent *P. filamentosa* (Pat.) Rogers and four new *Rhizoctonia* spp. described in a manuscript under preparation by H. Saksena and O. Vaartaja); *Cylindrocarpon* spp.; *Alternaria tenuis* Auct. *sensu* Wiltshire; *Gliocladium* spp.; and *Phoma* spp. *Phytophthora cactorum* was isolated commonly from one nursery in the rainy summers of 1954, 1955, and 1956.

A number of species isolated only occasionally were listed earlier (43). A few additional ones are: *Fusarium poae* (Pk.) Wr., *Cylindrocarpon obtusispora* (Che. & Hark.) Wr., *Helminthosporium* sp., and *Stachybotrys* sp. Bacteria were isolated from most seedlings, but seldom alone. *Streptomyces* spp. were sometimes frequent, but rarely alone. The same was true of a nematode, *Panagrolaimus* sp.

Most of the isolates were obtained from white spruce, *Picea glauca* (Moench) Voss; Colorado blue spruce, *P. pungens* Engelm.; jack pine, *Pinus banksiana* Lamb.; Scots pine, *P. sylvestris* L.; red pine, *P. resinosa* Ait.; and caragana, *Caragana arborescens* Lam.

Potential pathogenicity.—Representative isolates were tested for potential pathogenicity in tubes, with 5 aseptically germinated tree seeds in each tube. The method was essentially the same as used earlier (43) except that the medium was different (half-strength corn-meal agar) and the plants received more light (ca. 1500 ft-c).

A number of *Rhizoctonia solani* isolates, mostly belonging to *Pellicularia praticola*, were highly virulent on various plant species; others showed considerable variation. Similarly, many *Pythium* isolates were highly virulent and a few less so. Examples of the results with these and other fungi are given in Tables 1 and 2. For comparison, isolates are included from diseases other than damping-off. For instance, *Thielaviopsis basicola* isolates were mostly from rotting roots of seedlings of *Pinus resinosa*, of caragana (no. 2617), or of *Populus* sp. cuttings (2732A).

Table 1.—Potential pathogenicity of various fungi on seedlings of *Pinus banksiana* (in test tubes).

Species	No.	Health index[a]
Rhizoctonia solani (*P. praticola*)	1347	0
Rhizoctonia sp.	2352 & 2616	20
Rhizoctonia sp. (from mycorrhizal rootlet)	2287	20
Rhizoctonia sp.	1647	40
Rhizoctonia sp. (top blight)	1590	70
Phytophthora cactorum	1722	0
Phytophthora cinnamomi, *P. parasitica* (from U.S.A.)	2006 & 2009	0
Pythium debaryanum	1366	0
Pythium sp.	2233	5
Aphanomyces (? *euteiches* Drechs.)	1708	10
Fusarium oxysporum var. *redolens*	1654	0
F. poae	2380	2
F. roseum	2595	3
F. solani	2767	21
F. oxysporum var. *redolens*	1912	60
Cylindrocarpon sp. (rootlet)	2477A	40
C. obtusispora (top blight)	1595A	40
C. radicicola (top blight)	1823A	60
Helminthosporium sp.	2150 & 1730A	5
Thielaviopsis basicola (cuttings)	2017 B & 2732A	80
T. basicola (caragana root rot)	2617	20
Pestalotia truncata (rootlet)	2496	30
Stachybotrys sp.	2152	45

[a] Visual estimates of average relative growth when check seedlings = 100; 0 = no growth (all seeds killed).

Table 2 illustrates the potential pathogenicity of 16 isolates on different host progenies and seed lots. This test showed that the particular fungus-host combinations used in tests in soils could result in at least moderate disease. Some variation in potential pathogenicity was indicated among strains within *P. cactorum* and within *T. basicola*. Some small variation of susceptibility to certain pathogens was indicated among seed lots within a host species. This test failed to indicate such conspicuous differences within a host species as were found earlier (43). The tests gave highly reproducible results that agree with the results of similar earlier studies (41, 42, 43). They demonstrate potential pathogenicity for various isolates and give a firm basis for further studies with these. The

Table 2.—Virulence and susceptibility test: health of *Caragana arborescens* and *Pinus sylvestris* seedlings from various sources when grown in test tubes with pure cultures of fungal isolates.

		Health index[a] in 60 days									
		Caragana					Pine				
Fungal isolate		Misc. seeds		Progenies			Progenies		Misc. seeds		
Species	No.	309	142	AIP	VIP	21-16	54S	54N	183	259	249
Rhizoctonia sp.[b]	2777	80	80	35	55	40	45	45	20	90	65
R. solani	1347	0	0	5	0	*5*	*40*	25	15	5	5
Phytophthora cactorum	2173	0	0	0	0	0	0	40	20	0	15
	2153	0	0	0	25	16	0	30	15	15	15
	1722	15	5	15	5	*15*	*30*	–	60	15	45
Thielaviopsis basicola	2617	15	25	30	20	35	50	30	35	30	45
	2732A	40	60	60	65	*55*	*50*	30	0	35	20
	2848A_2	60	30	65	65	75	70	70	45	15	80
	Average 6 isol.[c]	73	76	74	91	69	75	71	69	59	67
Cylindrocarpon spp.	2722	60	20	20	60	10	0	40	–	70	5
	1832A	60	60	40	50	40	40	45	25	30	30

[a] Visual estimate of average relative growth when check seedlings =100; 0 = no growth (all seeds killed).
[b] 1347 was *P. praticola*; 2777 was a closely related new species, to be described elsewhere.
[c] Light-pigmented strains; 2617, 2732A were dark-pigmented, and 2848A_2 intermediate.

higher light intensity (1500 ft-c) than used earlier (250 ft.-c) provided a more sensitive measure of the virulent isolates. Less virulent isolates are fairly pathogenic at very low light intensities (35); this is of importance in forest stands but perhaps not in open nursery beds.

The test tube method is recommended for wider usage, provided that tests in sterile conditions are considered as indicating only the potential pathogenicity. Very rich media should not be used since this may cause excessive accumulation of toxins. In high concentrations the excretions from innocuous fungi are known to be toxic to plants (33).

Inoculations in unsterile soils.—*Isolates and hosts.*—The following isolates were selected for further study: a) *R. solani* (*P. praticola*) (no. 1347); b) *Pythium debaryanum* (no. 1366); c) *Phytophthora cactorum* (no. 1722); d) *Thielaviopsis basicola* (no. 2732A). Isolate (d) was pathogenic but less virulent than (a), (b), and (c); it was included as a control but was found to be pathogenic under certain conditions. The high virulence of (a), (b), and (c) on a variety of hosts has been established in many tests in addition to those of Tables 1 and 2. The isolates were obtained from the following hosts: (a) from *Picea glauca*, (b) and (c) from *Pinus sylvestris*, and (d) from diseased poplar cutting.

Interaction of the isolates was explored by growing them in pairs at the opposing edges of corn-meal agar plates and observing the mutual effects in all combinations. Similarly, the interactions were explored with the 2 saprophytes commonly associated with damping-off in the soils used (*F. solani* and *Cylindrocarpon* sp.), and with 3 common antagonists (*Penicillium* sp., *Trichoderma viride* Pers. ex. Fr., and a bacterium).

The host species used were caragana and Scots pine. Seeds were collected from one tree of each (AIP and 54S, Table 2) so that the genetic variation among the test plants would be small.

Methods.—1) Temperature.—Three different temperature conditions were provided in greenhouse compartments, each with additional lights for 16 hours daily. The mean temperatures and average daily ranges were: 1) 19°C (14–24); 2) 26° (24–30); and 3) 19°C (12–25).

2) Soil and moisture.—Six different "soils" were used: 1) virgin sod (Oxbow clay-loam) + 25% sand; 2) seedbed soil (originally as 1, used for 20 years with frequent manuring); 3) same as 2 but without weeds; 4) seedbed soil + 25% (sphagnum) peat; 5) seedbed soil sterilized with methyl bromide; 6) fungicide control, same as (2) but treated by mixing Orthocide [a wettable powder containing 50% captan (N-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide)] and Tersan [a wettable powder containing 75% thiram (bis(dimethylthiocarbamoyl) disulfide)] into soil prior to sowing, and spreading these periodically on the soil surface after seeding. The ratio was 2 parts of both fungicides to 1000 parts of soil by weight. The surface application was with water at 0.2 g of the fungicides per sq ft.

Clay pots containing the soils were packed in peat in a flat. The flats were maintained at 2 moisture levels by adding small amounts of water daily. The levels were ca. 70 and 100% as indicated by the Bouyoucos blocks and scale ("Moisture available to plants").

3) Inoculum potential.—The pots were inoculated either "lightly" or "heavily." Light inoculum contained chopped cultures grown on corn-meal agar, applied in suspension in water 2 days after sowing. Heavy inoculum contained chopped cultures grown in flasks in mixtures of vermiculite, sawdust, and dead conifer seeds (volume ratios 4:4:2), and water, sugar, and minerals; the cultures were mixed in the surface soils when a month old, at 1 teaspoonful per pot, 3 days before sowing. In particles such as sawdust, the fungi were well protected. They could be cultured from the flasks left for a year in laboratory rooms.

Phytophthora cactorum and *T. basicola* were recovered from the medium after this was allowed to dry until only 4% water (by weight) could be extracted from it at 110°C. The other species required somewhat moister media to survive.

Results.—1) General.—Seedling survivals were recorded 2 months after sowing, and calculated as percentages of seeds sown. Separate statistical analyses were made for the 2 host species and for the 2 inoculum potentials. Significant differences were calculated for *P* level .05 for data in Tables 4, 5, and 7.

In addition to damping-off, which caused low survival, caragana seedlings exhibited retarded growth and foliar discoloration in 2–3 months in soils treated with the fungicides. The edges of leaves and sometimes the whole leaves become chlorotic or brown, and died.

2) Light inoculum.—Results with light inocula were surprising. In contrast to results in earlier tests of Vaartaja and Cram (43), inocula in suspension now had little or no obvious effects on seedling survival.

The earlier tests (43) showed differences in seedling survival between *Rhizoctonia solani, Pythium debaryanum, Fusarium oxysporum* var. *redolens*, and *Alternaria tenuis*. In the new test, inoculation with fungi of obviously different pathogenic potential caused no significant differences. The effects of the inocula on the seedlings were perhaps masked by the greater effects of soil floras. Apparently the inoculum potentials of soil flora were weak in the earlier test (43). As a result the virulence indicated was great for the *R. solani* inocula and medium for the *P. debaryanum* inocula (isolates similar to those used in the present test). Weak virulence was indicated for *F. oxysporum*, and no conclusion could be drawn for *A. tenuis*.

On the other hand, there were great and significant differences between different soils, temperatures, and moistures in the present tests. Seedling survival was much higher in sterilized soils than in the unsterilized soils, indicating that light inocula caused less disease alone than when combined with soil flora. Survival was highest when both sterilization and fungicides were applied. These general results are illustrated by the examples of effects of moisture and temperature in Tables 4 and 5. Similarly to caragana (Table 5), pines were adversely affected by high moisture. The influence of temperature on caragana was rather small and interacted with moisture.

Survival in unsterilized soils differed only slightly, as exemplified by these means for caragana: seedbed soil, 35%; seedbed soil + peat, 38%; seedbed soil without weeds, 41%; virgin sod soil, 49%. For pine the order was the same.

3) Heavy inoculum.—Analyses of variance for heavy and light inocula on pine are compared in Table 6. Heavier inocula increased the effects of fungi (including F × S interaction) and cancelled those of other factors. This trend was still more obvious with caragana.

Heavy inoculum of each fungus had its own peculiar influence on seedling survival (Table 7). *R. solani* induced low survivals under all conditions. With *P. debaryanum*, survivals were relatively high, yet consistently lower than for light inoculum. *P. cactorum* and *T. basicola* were intermediate, but *T. basicola* allowed high survivals in the sterilized soil.

Survivals were generally lower with heavy inocula than with light inocula, including unsterilized soils; soil flora was relatively less important, and differences between unsterilized and sterilized soils were small, with certain exceptions. With *T. basicola*, survivals were high in the sterilized soil, and low in both unsterilized soils and controls (sterilized soil + fungicides).

With heavy inocula, differences in seedling survival between unsterilized soils were small and inconsistent. Similarly, differences between the 2 moisture levels were small and inconsistent except that survivals with *P. cactorum* were significantly lower in the moister soils.

In general, survival of caragana seemed to be favored by high temperatures, and that of pine by low temperature. This is in accordance with the germination speed of these species. One of the several exceptions was pine with *Thielaviopsis* inocula (no temperature effects). Survival of caragana with *Thielaviopsis* inocula was 61% at high temperatures, and 22% at low.

4) Reisolation.—Two diseased and two healthy pine seedlings were taken from each of the high-temperature pots each week and treated with 0.5% $HgCl_2$. A piece of root collar of the border area of healthy and diseased tissues was cut off, rinsed, and plated on agar. Table 8 summarizes the records of fungi isolated.

Fusarium oxysporum and especially *F. solani* were isolated very frequently from diseased seedlings. Because they were commonly isolated even from healthy seedlings, they did not seem to occur as virulent pathogens. The same is true with bacteria and miscellaneous fungi that were fairly frequent in seedlings from all soils. Although the same *Fusarium* isolates, according to the pure-culture inoculation test, possessed high potential virulence, they did not cause symptoms, at least in many seedlings that they had parasitized or on which they occurred epiphytically.

In soils with *Rhizoctonia* inocula, *R. solani* was frequently isolated from diseased seedlings and rarely from healthy seedlings. Similarly, in soil with *Pythium* inocula, *Pythium* spp. were frequently isolated from diseased seedlings and rarely from healthy seedlings. The rare occurrence of *Rhizoctonia* and *Pythium* in "healthy" seedlings was assumed to be a result of unavoidable errors in selecting healthy seedlings; a few were selected that had an incipient or arrested symptomless infection.

Some seedlings from unsterilized soils in treatments other than *Rhizoctonia* and *Pythium*, particularly with light inocula, nevertheless contained these fungi, especially *Pythium*. Such naturally occurring *Pythium* was not isolated from seedlings in sterilized soils. This suggests that in sterilized soils the mortality was caused not by the reinfestation flora but by the inocula. The reisolation percentage from diseased seedlings

Table 3.—Interaction of pairs of fungal cultures in various combinations in corn-meal agar dishes.

Effect by	Effects[a] on isolate no.					
	1347	1366	1722	2732A	2767	2771
R. solani		0	-	-	+	-
1347		-	---	-	+	-
P. debaryanum	0		0	-	+	-
1366	---		---L	--		---
P. cactorum	+	0		0	0	-
1722	+	0		0	0	-
T. basicola	-	0	0		-	-
2732A	-	0	---		---	-
F. solani	--	0	+?	0		0
2767	--	0	---	-		--
Cylindrocarpon sp.	0	0	-	-	0	
2771	L	0	---	-	--	
Penicillium	--	-	-	-	-	-
spp.	L	L	---L	---	---	--
Bacterium	-	-	-	-	-	-
spp.	-	-	---	---	--	--
Trichoderma	-	0	-	-	-	-
viride	---	--L	---L	---	---	---
Streptomyces	-	-	-	-	-	-
spp.	---	--L	---L	---	---	---

[a] - = growth reduced slightly; -- = growth reduced considerably; --- = growth stopped; + = stimulation; L = lysis; 0 = no effect.
[b] 2732A was a dark type of *T. basicola* known to be especially sensitive to bacterial antagonism (34).
Upper line shows the effect before the colonies contacted each other; lower line shows the effect after contact.

was somewhat higher with heavy than light inocula. *Thielaviopsis basicola* was not reisolated.

An attempt was also made to isolate the root pathogens causing the leaf symptoms. In addition to commonly found species of *Fusarium*, only a few isolations of *Rhizoctonia* spp. and *T. basicola* were obtained. In a more elaborate attempt during the previous winter, *T. basicola* was commonly isolated from roots of caragana showing similar symptoms. This fungus is possibly the pathogen, but perhaps it can be isolated only at a certain stage of the disease.

Interpretation of the results.—The lack of effects by fungi, the increased tree survival by soil sterilization, and the reisolation data indicated that with light inocula the mortality was caused mainly by soil flora, especially *Pythium* spp. Therefore, the various environmental effects (Tables 4 and 5), at least in the unsterilized soils, should be attributed chiefly to the responses of *Pythium* spp. No conclusions or generalizations could be made on the responses of the inoculum fungi.

With heavy inocula, Koch's postulates were fulfilled for *Rhizoctonia solani*, *Pythium debaryanum*, and *Phytophthora cactorum*. *P. cactorum* is slow-growing, easily suppressed by other fungi and bacteria (Table 3), and usually very difficult to isolate. Therefore, the relatively low reisolation incidence of this fungus should not invalidate the conclusion about its pathogenicity, based on high mortality of seedlings (Table 7).

Conclusions about the pathogenicity of *T. basicola* are postponed since it showed only moderate potential pathogenicity in test tubes, is not known to be associated with damping-off and was not reisolated in tests in soils. The high mortality with *T. basicola* may have been an artifact due to excessive inoculum and conditions favoring disease. A less likely possibility is that *T. basicola* is an important cause of damping-off but is commonly overlooked because of isolation difficulties.

The potentials of the heavy inocula were probably stronger than is usual in seedbeds (perhaps especially

Table 4.—Survival[a] of *Pinus sylvestris* in different soils under three temperature conditions with light inocula (results of all fungi and both moistures combined).

Soil	Temperature			Mean
	High	Low	Variable	
Unsterilized soils (av.)	14	25	31	23
Sterilized seedbed	37*	61*	51*	50*
Fungicide control	68*	61	64	65*
Mean	29	39**	42	

[a] As % of seed sown.
* Significantly greater than for preceding soil.
** Significantly greater than for high temperature.

Table 5.—Survival[a] of *Carragana arborescens* in different soils of low and high moisture with light inocula (results of all fungi and temperatures combined).

Soil	Moisture		Mean
	High	Low	
Unsterilized soils (av.)	23	59	41
Sterilized seedbed	72*	80*	76*
Fungicide control	92*	92*	92*
	43	68**	55

[a] As % of seed sown.
* Significantly greater than for preceding soil.
** Significantly greater than for high moisture.

so with *T. basicola*, which produces masses of endoconidia in culture). Therefore, the results from tests with heavy inoculum should be generalized not to normal seedbed conditions but perhaps to unusually poor sanitation conditions after heavy epidemics have developed without application of control measures.

Seedling survival was expected to be higher in unsterilized than in sterilized soils as a result of biological control by soil floras (Table 3) (43). Soil floras were more virulent than any of the light inocula, however, and no biological control could be demonstrated. With heavy inocula, soil floras mostly did not make much difference except that *T. basicola* was controlled more effectively by the reinfestation floras than by the original floras.

Soil floras, original or new, prevented the mortalities from reaching the same incidences as in the test tubes, except with the heavy *Rhizoctonia* inoculum. The sterilized soils were soon colonized by bacteria, *Fusarium* spp., and *Penicillium* spp., which appear antagonistic to the pathogens (Table 3).

The fungicide treatment with captan and thiram gave considerable increase in seedling survival. This was about as large (av. 14–16%) with light as with heavy inocula, but at a higher level with light inocula. Control was greatest on *P. cactorum* (caragana survivals increased from 11 to 63%); with *Rhizoctonia*, fungicides increased survivals from 3 to 30%; with *T. basicola*, fungicides decreased survivals, perhaps by interfering with useful antagonism in soil.

Heavy inoculum may be used to produce enough mortality for significant differences in fungicide trials. The conclusions may not apply to normal field conditions, however, except perhaps to very serious epidemics such as occurred at one nursery in 1953, when 95% of the conifer crop was lost.

Discussion.—*Etiology.*—There is a paradox: to study what actually happens in epidemics in seedbeds, inoculation experiments should be done in undisturbed, unsterilized seedbed soil; but when a naturally infested soil is inoculated with additional pathogens, the disease may not increase significantly. In this study, high mortality was caused only by very heavy inocula, which of course disturbed the soil. This, together with the problems discussed in the introduction, suggests that studies of the etiology of damping-off should be limited to testing the potential pathogenicity of isolates. To avoid unpredictable effects of soil floras and aerial contaminants, the tests should be done in sterilized media in jars or test tubes. With such standardized screenings many fungus strains can be rapidly tested on many host strains. This seems necessary considering the recent findings of variability in pathogenicity and susceptibility (Tables 1 and 2) (18, 20, 34, 43). The etiological method based on Koch's postulates can hardly go further in damping-off. Applying heavy inocula will be a useful research tool in screenings of fungicides that will later be tested in seedbeds.

To learn what actually happens under different seedbed conditions requires comprehensive epidemiological studies. It becomes necessary to develop new methods to investigate the natural inoculum in undisturbed soils and on the surfaces of the plants. This is gradually being realized in studies on many root diseases (12). It is especially true with damping-off, which may be caused by various fungi.

Results in Table 6 emphasize the importance of inoculum potential (as discussed by Garrett, 12) and agree with other recent reports. For instance, *Fusarium* and *Gliocladium* inocula are more virulent on clover seedlings if grown in a medium of seeds than if grown in agar or liquids (27). New isolation methods (5), especially with various types of bait (3, 19, 22, 28), may greatly facilitate studies of the natural inoculum in soils.

Effects of soils.—The different soils, other than the sterilized ones, were associated with slight differences in disease. With light inocula the differences, although of the anticipated order between the soils, were not significant. The naturally present pathogens were fairly potent even in virgin sod soil. Similarly, both *Pythium* and *Rhizoctonia* damping-off have been found in a prairie nursery the first year after beds were cleared from aspen forest on slightly acid sand (39). On the the other hand, very acid types of forest humus reduce damping-off (3, 26, 35). Powdered leaves and bark from various tree species have reduced *R. solani* damping-off, whereas humus from certain forest stands did not (40). The antibiotics of the leaves and bark may exert a protecting effect, but this probably lasts for a significant duration only under very acid conditions that reduce decomposition. This would explain the published (37) and similar unpublished results during 7 years in a nursery where incorporation of a ½-in. layer of slightly acid forest humus in seedbed soil failed to give adequate control.

Similarly, the protective effect of peat was insufficient in the greenhouse test; it has also been insufficient in laboratory (40) and field tests (37, and unpublished results).

This does not mean that utilizing virgin soils or plant materials, including acid sphagnum peat, should not be recommended. Indeed, under conditions less conducive to damping-off, they may exert worthwhile effects in various ways. These are: a) protection by

Table 6.—Analyses of variance for survivals of *Pinus sylvestris* with light and heavy inocula.

Source of variation	D. F.	M.S. Light	M.S. Heavy
Fungi (F)	3	1.6	43.4**
Soils (S)	4	67.3**	51.5**
Moisture (M)	1	43.3**	0.1
Temperatures (T)	2	18.0**	8.6**
F × S	12	1.2	5.5**
F × M	3	2.8*	2.0*
F × T	6	1.1	1.4*
S × M	4	4.5**	2.6*
S × T	8	4.3**	1.3
M × T	2	5.6**	0.6
Triple intera. + residual	74		
	119		

P levels: *.05; **.01

Table 7.—Survival[a] of *Pinus sylvestris* and *Caragana arborescens* in different soils with heavy inocula of four fungi (results of different temperatures and moistures combined).

	R. solani	*P. cactorum*	*T. basicola*	*P. debaryanum*	Mean
1. *Pinus sylvestris*					
Unsterilized soils (av.)	2	13	7	25	12
Sterilized seedbed soil	6	34*	47*	22	27*
Fungicide control	34*	49*	43	45*	43*
Mean	9	25**	22	29**	
2. *Caragana arborescens*					
Unsterilized soils (av.)	0.3	13	33	63	36
Sterilized seedbed soil	0	11	72*	72	52
Fungicide control	25	63*	59	82	68*
Mean	4.4	21**	43**	68**	

[a] As % of seed sown.
* Significantly greater than for preceding soil.
** Significantly greater than for preceding fungus.

antibiotics from leaves and bark (40); b) increased resistance of conifers through increased acidity (14); and c) microbial buffering (11, 12, 35, 42).

Effects of moisture.—The tendency of increased disease with increased moisture was marked in certain cases, especially with the virulent natural soil flora, mainly *Pythium* spp., and with heavy inoculum of *Phytophthora cactorum*. This is to be expected, since these fungi may spread by zoospores. This is also in accord with isolation data in various nurseries (38) and with experimental results on similar diseases (1, 4, 13, 15, 29, 30, 31, 44). In 1953 the losses were 95% at Indian Head after heavy rains that supposedly rendered ineffective the fungicides applied. According to Zwet (45), root rot of sugarcane by *P. arrhenomanes* Drechs. can be induced only by flooding the soil. Temporarry flooding is frequent in seedbeds during rains but is usually avoided in experiments. This may explain why the main pathogen seemed to be *Pythium* as judged from isolations, but *R. solani* as judged from inoculations (Tables 5 and 6) (43). High moisture is also reported to favor *T. basicola* (18).

Rhizoctonia spp. are less exacting and are reported to be favored sometimes by high moisture, and sometimes by low, perhaps because their strains vary in water and oxygen requirements (1, 8, 10, 19, 20, 30, 44).

Effects of temperature.—The effects of temperature varied greatly and interacted with other factors. The effect was greatest with heavy *T. basicola* inoculum on caragana; survivals at lower temperatures were 1/3 of those at higher ones. The cool humid greenhouse conditions may favor this fungus in some way. Martin and Ervin (24) reported great increases of *T. basicola* in pots with citrus seedlings in the greenhouse. This caused foliar symptoms on citrus leaves (23), resembling those reported here on caragana.

Antagonistic flora.—According to Boosalis and Scharen (5), 100 g of soil may contain 6800 debris particles infested with living *R. solani* 7 months after sugar beet crops. With such inoculum and with 100% disease potential demonstrated in test tubes (Tables 1 and 2), all seedlings should be killed by *R. solani* in seedbeds. This obviously is not the case, and damping-off incidence varies from time to time and from spot to spot in a bed. Factors regulating this variation are perhaps found in antagonistic flora (Table 3) (11, 12, 34, 36, 43) and in the peculiar lytic (21) and fungistatic effects (16) commonly found in undisturbed soils. These effects, in turn, must be influenced by weather factors, but probably in a complex, perhaps unpredictable, way. This situation may also apply to damping-off caused by such common isolates as *Pythium* spp. and, in certain nurseries, *P.*

Table 8.—Isolations[a] from diseased (D) and healthy (H) seedlings of Pinus sylvestris from the high temperature conditions (both types of inocula combined).

		Isolations							
		R. solani		Pythium sp.		P. cactorum		Fusaria[b]	
Inoculum	Soil groups	D	(H)	D	(H)	D	(H)	D	(H)
Rhizoctonia solani	Unsterilized	++	(-)	++	(-)	-	(-)	++	(++)
	Sterilized	+++	(++)	-	(-)	-	(-)	++	(++)
Pythium debaryanum	Unsterilized	-	(-)	++	(-)	-	(-)	+++	(+++)
	Sterilized	-	(-)	++	(-)	-	(-)	+++	(++)
Phytophthora cactorum	Unsterilized	-	(-)	++	(-)	++	(-)	+++	(++)
	Sterilized	-	(-)	-	(-)	-	(-)	+++	(++)
Thielaviopsis basicola	Unsterilized	+	(-)	++	(+)	-	(-)	+++	(+++)
	Sterilized	-	(-)	-	(-)	+	(-)	+++	(++)

[a] Isolation incidence: -, 5%; +, 5–10%; ++, 10–30%; +++, 30%. Reisolations are boxed.
[b] Mostly *F. solani*.

cactorum. Furthermore, the importance of many other fungi that are less commonly isolated, but potentially pathogenic (Tables 1 and 2), may be governed by these biological factors. Thus, Arndt (2) found that a large number of common fungi are potentially capable of killing cotton seedlings at a wide temperature range, but, obviously, most of them are usually inhibited from doing so in unsterile soil.—Forest Biology Section, Canada Agriculture Research Station, Saskatoon, Saskatchewan, Canada, and Forest Nursery Station, Indian Head, Saskatchewan, Canada.

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REPORT OF THE 52nd ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The 52nd Annual Meeting of the American Phytopathological Society was held at the American Baptist Assembly, Green Lake, Wisconsin, August 28 to August 31, 1960. This meeting was in conjunction with the North Central Division of the American Phytopathological Society, and with the Potato Association of America. Attendance of Society members was estimated at 750; total attendance, including families, was 1,356. The program consisted of a Symposium on Plant Disease Losses, sponsored by the Committee on Plant Disease Losses; a Symposium on Weather and Plant Disease, sponsored by the Committee on Agricultural Meterology; a Fungicide Colloquium; and 224 contributed papers on original research divided into sections on Disease Epidemiology, Diseases of Fruit, Bacterial Diseases, Fungicides and Seed Treatment, Diseases of Field and Forage Crops, Potato Diseases, Nematology, Physiology of Pathogens, Fungicides and Chemotherapy, Fungus Genetics, Virology, Diseases of Vegetables, Soil Microbiology and Root Diseases, Diseases of Forest Trees, Disease Resistance, Physiology of Diseased Plants, Diseases of Ornamentals, Virus Diseases, and Diseases of Cereals.

The program for the Symposium on Plant Disease Losses, under the chairmanship of J. R. Shay, was as follows:

Recent activities in plant disease loss determinations. J. R. Shay, Purdue University.

Industry's need for plant disease loss information. R. H. Wellman, Union Carbide Chemicals Co., New York.

Aerial photography as an aid in estimating crop losses. R. N. Colwell, University of California, Berkeley.

The program for the Symposium on Weather and Plant Disease, under the chairmanship of E. P. Van Arsdel, was as follows:

Weather instruments for the study of plant diseases. P. M. Kuhn, U. S. Weather Bureau, Madison.

Controlled chambers for epidemiological research. R. D. Schein, Pennsylvania State University.

Turbulent transfer of fungus spores. Alice L. Robert, U. S. Department of Agriculture, Beltsville.

Weather, space, time, and the chance of infection. P. E. Waggoner, Connecticut Agricultural Experiment Station.

The Fungicide Colloquium, under the chairmanship of Saul Rich, was organized as follows:

Prospects for an antiviral agent. W. E. Rader, Shell Development Co., Modesto, California.

Cooperative planning for research on pesticides. Noble Clark, Wisconsin Agricultural Experiment Station.

The tenuous trail from tube to trial. R. A. Ludwig, Canada Department of Agriculture, Kentville, N.S.

The Council met on August 28, August 29, and August 31. One general business meeting of the Society was held on August 30, from 9:00 AM to 10:45 AM. The Annual Banquet was held on Tuesday evening, August 30, with approximately 650 in attendance. The North Central Division held a business meeting Wednesday morning, August 31.

The 50th Anniversary celebration of the Department of Plant Pathology, University of Wisconsin, was held in the form of a banquet and evening program, on Monday evening, August 29, with over 350 in attendance. J. G. Dickson, G. W. Keitt, A. J. Riker, J. C. Walker, and Gerald Thorne were honored in the evening's program.

Other special meals were held by the following groups: Cornell University, University of Minnesota, University of California, Ohio State University, Extension Plant Pathologists, and Potato Association of America.

Informal Conferences were held on Diseases of Ornamental Plants, under the chairmanship of A. C. Hildebrandt; on Seed and Soil Treatment, under the chairmanship of T. C. Ryker; and on Nematodes, under the chairmanship of J. N. Sasser.

The following committees met during the four-day meeting: Regulatory Work and Foreign Plant Diseases, Phytopathological Monographs, Plant Disease Losses (A.P.S. and N.R.C. committees), Teaching, International Cooperation, Virus Type Culture Collection, Meteorology and Epidemiology, Program, Special Committee to Study Publications and Public Relations, Phytopathological Monographs and Reviews, Soil Microbiology, and Sourcebook.

A number of tours were arranged by the Department of Plant Pathology, University of Wisconsin, both before and after the meeting. The Department also held an Open House at Madison on September 1.

The Committee on Local Arrangements for this meeting consisted of: E. W. Hanson, Chairman, H. M. Darling, J. D. Moore, and G. S. Pound, with the following serving as subcommittee chairmen for the various phases: J. G. Berbee, D. J. Hagedorn, A. C. Hildebrandt, Mr. and Mrs. J. E. Kuntz, R. H. Larson, J. E. Mitchell, J. D. Moore, R. F. Patton, G. S. Pound, Mrs. G. S. Pound, and E. K. Wade.

ORGANIZATION OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY 1961

Council:

S. E. A. McCallan, President, Boyce Thompson Institute for Plant Research.

William B. Hewitt, President-Elect, University of California, Davis.

C. S. Holton, Vice-President, Washington State University.

William C. Snyder, Immediate Past President, University of California, Berkeley.

GEORGE A. ZENTMYER, Secretary, University of California, Riverside.

A. W. DIMOCK, Treasurer and Business Manager of PHYTOPATHOLOGY, Cornell University.

ROBERT W. FULTON, Editor-in-Chief, University of Wisconsin.

ARTHUR KELMAN, Councilor-at-Large, North Carolina State College.

ALBERT L. TAYLOR, Councilor-at-Large, USDA Plant Industry Station, Beltsville.

M. B. LINN, Councilor of North Central Division, University of Illinois.

E. M. STODDARD, Councilor of Northeastern Division, Connecticut Agricultural Experiment Station.

B. R. HOUSTON, Councilor of Pacific Division, University of California, Davis.

L. O. WEAVER, Councilor of Potomac Division, University of Maryland.

WOODROW W. HARE, Councilor of Southern Division, Mississippi State University.

Representatives:

A.A.A.S. Council: H. A. Rodenhiser (2 yrs., expires Dec. 31, 1961); J. G. Leach (2 yrs., expires Dec. 31, 1962).

A.I.B.S. Board of Directors: George L. McNew (4 yrs., expires Dec. 31, 1961).

Agricultural Research Institute, National Research Council: L. O. Weaver; W. D. McClellan, Alternate.

Division of Biology and Agriculture, National Research Council: Russell B. Stevens (3 yrs., expires June 30, 1961); William C. Snyder (3 yrs., expires June 30, 1964).

Food Protection Committee, Food and Nutrition Board, National Research Council: Wilson L. Smith, Jr.

Board of Editors, American Journal of Botany: E. E. Wilson (3 yrs., expires Dec. 31, 1963).

American Type Culture Collection: J. A. Stevenson; R. L. Steere, Alternate.

Associates Food and Container Institute: M. A. Smith.

Biological Stain Commission, Board of Trustees: Shirl O. Graham.

American Standards Association Sectional Committee on Common Names for Pest Control Chemicals, K62: W. D. McClellan; S. E. A. McCallan, Alternate.

American Grassland Council: Earle W. Hanson; John R. Hardison, Alternate.

Editors of PHYTOPATHOLOGY:

Terms expire Dec. 31, 1961: George W. Bruehl, E. C. Calavan, Max W. Gardner, W. F. Rochow, Edwin B. Williams.

Terms expire Dec. 31, 1962: J. M. Daly, J. G. Horsfall, William F. Mai, John H. Owen, Hugh D. Sisler.

Terms expire Dec. 31, 1963: R. R. Baker, George B. Lucas, Lawrence P. Miller, Robert F. Patton, T. C. Vanterpool.

Standing Committees:

Program: W. B. Hewitt, Chairman, ex-officio; Robert S. Dickey, M. E. Gallegly, Paul F. Hoffman, Arthur Kelman, Paul R. Miller, Saul Rich, W. F. Rochow, D. A. Slack, Harlan E. Smith, W. C. Snyder, Paul E. Waggoner, John C. Walker, Lansing E. Williams, George A. Zentmyer.

General Committees:

Archives: Paul R. Miller, Chairman; Edward E. Butler, Karl Maramorosch, S. E. A. McCallan.

Extension: Harlan E. Smith, Chairman; Gordon A. Brandes, M. P. Britton, H. G. Johnson, J. G. Kantzes, I. A. MacSwan, A. O. Paulus, E. Sharvelle, Arden F. Sherf.

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Industry: Paul F. Hoffman, Chairman; T. C. Allen, Jr., E. E. Feichtmeir, John B. Harry, T. C. Ryker, N. C. Thornton, Joseph S. Tidd, W. J. Virgin.

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Membership: C. S. Holton, Chairman, ex-officio; George W. Bruehl, D. F. Crossan, E. F. Darley, A. W. Dimock, ex-officio, W. J. Hooker, F. J. Lebeau, J. E. Livingston, J. Ohman, Luis Sequeira, J. B. Sinclair, E. B. Smalley, John E. Thomas, John Tuite, N. N. Winstead.

Placement: H. Rex Thomas, Chairman; E. J. Cairns, William E. Cooper, G. C. Kent, L. D. Leach, Roy A. Young.

Publications: A. Frank Ross, Chairman; R. W. Fulton, A. B. Groves, J. G. Horsfall, L. C. Knorr, K. W. Kreitlow.

Phytopathological Classics: L. C. Knorr, Chairman; Robert S. Dickey, John C. Walker.

Phytopathological Monographs and Reviews: J. G. Horsfall, Chairman; John S. Boyce, Jr., Helen Hart, Harold J. Jensen, R. B. Stevens, H. E. Wheeler.

Phytopathological News Page: K. W. Kreitlow, Chairman; S. H. Davis, D. E. Ellis, R. A. Fredricksen, J. F. Fulkerson, Shirl O. Graham, W. E. Sackston, L. O. Weaver.

New Fungicide and Nematocide Data: A. B. Groves, Chairman; Gordon A. Brandes, S. H. Davis, Charles J. Delp, John W. Heuberger, Fred H. Lewis, J. N. Sasser.

Public Relations: Paul R. Miller, Chairman;

John B. Harry, Eugene B. Hayden, Paul F. Hoffman, C. E. Horner, J. B. Kendrick, Jr., T. H. King, G. B. Lucas, L. Gordon Utter, John L. Weihing, Russell B. Stevens, L. O. Weaver.

Regulatory Work and Foreign Plant Diseases: G. L. Stout, Chairman; Earle C. Blodgett, J. G. Dickson, Joseph P. Fulton, George H. Hepting, Robert P. Kahn, Gerald Thorne, W. H. Wheeler, Stephen Wilhelm.

Teaching: Arthur Kelman, Chairman; C. W. Boothroyd, D. F. Crossan, I. W. Deep, D. W. French, John E. Mitchell, John H. Owen, G. K. Parris, Lewis F. Roth, Thomas Sproston, R. B. Stevens, Robert Zabel.

Subject Matter Committees:

Bacteriology: Robert S. Dickey, Chairman; Peter A. Ark, B. A. Friedman, Arthur Kelman, A. J. Riker, R. M. D. Sutton.

Chemical Control: Saul Rich, Chairman; C. H. Graves, Jr., J. B. Kendrick, Jr., W. A. Kreutzer, Robert G. Owens, B. L. Richards, Jr., David E. Schlegel, Hugh D. Sisler.

Disease and Pathogen Physiology: John C. Walker, Chairman; D. F. Bateman, V. W. Cochrane, J. M. Daly, J. E. DeVay, R. D. Durbin, Joseph Kuc.

Epidemiology and Meteorology: Paul E. Waggoner, Chairman; Robert V. Bega, Russell A. Hyre, Thomas H. King, S. M. Pady, Lee H. Persons, E. P. Van Arsdel, J. R. Wallin.

Host Resistance and Microbial Genetics: M. E. Gallegly, Chairman; D. M. Boone, Ralph M. Caldwell, A. H. Ellingboe, Harold H. Flor, Gordon J. Green, John G. Moseman, Harry E. Wheeler.

Mycology: W. C. Snyder, Chairman; Edward E. Butler, William L. Gordon, George B. Lucas, Charles G. Shaw, E. B. Smalley.

Plant Nematology: D. A. Slack, Chairman; G. B. Bergerson, E. J. Cairns, H. M. Darling, M. B. Harrison, W. B. Mountain, J. N. Sasser, Ivan J. Thomason.

Plant Virology: William F. Rochow, Chairman; J. B. Bancroft, Robert W. Fulton, H. H. McKinney, Ellen L. Moorhead, J. T. Slykhuis, R. L. Steere, W. N. Takahashi.

Soil Microbiology: Lansing E. Williams, Chairman; K. F. Baker, Ralph Baker, M. G. Boosalis, A. W. Dimock, J. E. Mitchell, G. C. Papavizas, G. A. Zentmyer.

Special (Temporary) Committees:

Plant Disease Losses: J. Ralph Shay, Chairman; J. C. Carter, E. L. LeClerg, Paul R. Miller, Albert L. Smith, G. L. Stout, Albert L. Taylor.

Special Committee to Study Publications and Public Relations: J. G. Horsfall, Chairman; A. W. Dimock, E. B. Hayden, W. B. Hewitt, S. E. A. McCallan, Paul R. Miller, A. F. Ross, W. C. Snyder, G. A. Zentmyer,

REPORTS OF OFFICERS, COMMITTEES, AND REPRESENTATIVES

Report of the Secretary. As of December 31, 1959, the Society had 1,999 members, which included 1.861 regular members, 108 Life members, and 30 Emeritus members. During 1959, 176 new member applications were accepted; of these 56 were regular and 120 student members. As of July 1, 1960, there were 2,093 members of the Society; new member applications for the first six months of 1960 totaled 103, with 34 regular and 69 student applications. The following members have passed away since the 1959 meeting: Floyd D. Bailey, R. K. Beattie, Carroll E. Cox, Bliss F. Dana, B. O. Dodge, Howard A. Edson, H. N. Hansen, Lon A. Hawkins, Takewo Hemmi, Godfrey R. Hoerner, J. R. Kienholz, L. O. Kunkel, Ellsworth C. Maine, Gerardo O. Ocfemia, J. K. Richardson, W. B. Saunders, C. M. Slagg, Albert W. Slipp, Errett Wallace.

GEORGE A. ZENTMYER

Report of the Treasurer-Business Manager. The accompanying summaries of American Phytopathological Society and PHYTOPATHOLOGY accounts show that expenses for regular Society functions amounted to $6,383.23, including $596.75 advance payment for 1960-61 secretarial services. In addition, $9,517.85 was disbursed from special grant funds. The relatively small balance of $279.82 in the APS account, though not a cause for alarm, reflects failure of income from dues to keep pace with rising costs.

The PHYTOPATHOLOGY account is somewhat inaccurate since the bill for manufacture and distribution for June had not been received at the time the report was prepared. This bill, amounting to $2,561, raises the cost of manufacture and distribution for the 12 issues, July 1959-June 1960, to $29,814 and total expenditures to $43,313. Income thus was about $1,000 short of meeting expenses. The increase in cost of manufacture and distribution over the previous 12 issues, amounting to about $3,750, was due entirely to an increase in number of papers published, a trend which probably will continue.

Part of the reason for failure to balance income against expenses is evident when it is noted that the cost for the last volume of 12 issues was $11.25 per set, the cost per member for regular APS activities was $2.82, and thus total cost per member was $14.07. Of our 2,048 members who currently receive PHYTOPATHOLOGY, over 200 are student members paying only $5 per year, 105 are paid-up Life members, and the remaining members pay only $10 per year. Even though the additional revenue realized from increasing non-member subscriptions to $15 per year may help balance the PHYTOPATHOLOGY account, it is evident that membership dues should be brought more in line with costs. Otherwise, expenses incurred in carrying forward the very important activities of our committees will quickly erode our reserves.

A. W. DIMOCK

FINANCIAL STATEMENT
AMERICAN PHYTOPATHOLOGICAL SOCIETY
(Including PHYTOPATHOLOGY)
Fiscal Year Ended June 30, 1960

AMERICAN PHYTOPATHOLOGY SOCIETY

RECEIPTS:

Balance on hand July 1, 1959		$ 8,543.00
Membership dues	$3,987.90	
NSF Grant G4605 (50th Ann. Vol.)	3,650.00	7,637.90
TOTAL		$16,180.90

EXPENDITURES:

Office of President	$ 0.00	
Office of Secretary (including $596.75 for steno 1960-61	2,840.72	
Office of Treasurer	607.85	
Dues, AIBS, 1960	1,775.00	
Dues, American Grassland Council	10.00	
Expenses, Annual Meeting 1959	482.32	
Expenses, Public Relations Committee	438.50	
Expenses, Phytopath News	32.19	
Expenses, APS film "Design for Abundance"	196.65	
Expenses, NSF 5775 (Bibliography of Reviews)	2,340.89	
Expenses, NSF 8380 (Sourcebook on Teaching)	1,660.84	
Trans. to University of Wisconsin Press (Jubilee Vol. 4605)	2,847.67	
Refund, balance Rockefeller Grant GA 5677	$2.668.45	$15,901.08
BALANCE, June 30, 1960		$ 279.82

Expenditures minus all grant money = $6,383.23
Amount disbursed from special grant funds = $9,517.85
Grant money remaining in APS accounts = $9,053.18

PHYTOPATHOLOGY

RECEIPTS:

Balance on hand July 1, 1959		$23,640.92
Subscriptions and member-subscriptions	$28,766.91	
Advertisements	2,091.50	
Reprints and excess illustrations	6,634.49	
Interest on investments*	1,938.24	
Sale of back issues	1,695.38	
Sustaining associates	1,200.00	
Premiums, foreign checks	1.89	42,328.41
TOTAL		$65,969.33

**Cash dividends only; accrued interest not included.*

EXPENDITURES:

Manufacture and distribution—PHYTOPATHOLOGY	$27,253.66	
Cost of reprints	2,455.08	
Office of Business Manager	2,147.57	
Office of Editor-in-Chief	6,521.84	
Office of Advertising Manager	550.35	
Cost of new investments	197.88	
Refunds	176.34	
Director of Internal Revenue	1,449.10	40,751.82
BALANCE, June 30, 1960		$25,217.51

TOTAL BALANCE APS & PHYTOPATHOLOGY, June 30, 1960 $25,488.68

INVESTED FUNDS

Values as of June 30, 1960. Dividends and Interest for the Fiscal Year July 1, 1959 to June 30, 1960

SINKING FUND:

	Value 6/30/60	Earnings 1959-60
U. S. Savings Bonds, Ser. J	$ 1,945.00	$ 70.00
U. S. Savings Bonds, Ser. F	24.05	.83
U. S. Savings Bonds, Ser. E	389.60	11.60
Northwestern Fed. Sav. & Loan Certificate	2,000.00	80.00
Lawn Savings & Loan Certificate	8,000.00	330.00
Family Finance Corp., 90 sh.	2,655.00	144.00
Westinghouse Electric Corp., 44 sh.	2,524.50	50.60
Standard Oil of Ohio, 60 sh.	2,745.00	150.00
American Cyanamid, 100 sh.	5,737.50	160.00
Johns Manville, 71 sh.	4,393.31	142.00
American Tel. & Tel., 24 sh.	2,142.00	79.20
General Electric, 25 sh.	2,306.25	50.00
Pacific Lighting, 40 sh.	1,975.00	96.00
Boston Fund, 622 sh.[a]	10,704.62	247.50
Wellington Fund, 496 sh.[b]	6,968.80	229.60
	$54,510.63	$1,841.33

[a] 22 sh. accepted as capital gains distribution 2/29/60. 210 sh. purchased 3/10/60.
[b] 16 sh. accepted as capital gains distribution 12/29/59.

LYMAN MEMORIAL FUND:

Westinghouse Electric Corp., 70 sh.	$4,016.25	$ 80.50
Amer. Tel. & Tel. 66 sh.	5,891.50	217.80
	$9,907.75	$ 298.30

PHYTOPATHOLOGY CONTINGENCY FUND:

Arlington-Fairfax Savings & Loan	$ 8,470.51	$ 319.62
Arundel Federal Savings & Loan	9,850.18	405.65
Southern Federal Savings & Loan[c]	5,418.14	329.05
Decatur Federal Savings & Loan	9,406.66	365.26
Fidelity Federal Savings & Loan	8,861.48	372.06
California Federal Savings & Loan[c]	5,355.33	326.38
Southwest Savings & Loan	8,671.51	364.05
Prudential Building Association	7,435.40	290.13
Tompkins County Trust Co.	591.61	16.61
Ithaca Savings Bank	5,190.00	100.00
First National Bank, Ithaca	585.22	16.47
	$69,836.04	$2,905.28

[c] $5,000 withdrawn from both Southern and California 2/8/60 for general expenses.

TOTAL INVESTED FUNDS $134,258.42 $5,044.91

Report of the Auditing Committee. The undersigned committee has examined the financial records of the American Phytopathological Society and PHYTOPATHOLOGY for the fiscal year ending June 30, 1960. It is our opinion that all receipts, expenditures, and funds were properly and accurately recorded and in order. All securities, government bonds, savings and loan accounts, and savings accounts were found to be present, and in the amounts listed in the Treasurer's report, in the Society's safe-deposit box in the Tompkins County Trust Company, Ithaca, New York.

R. M. GILMER, Chairman
K. G. PARKER
C. W. BOOTHROYD

Report of the Editor-in-Chief. Material published in the September-December numbers of Volume 49

was not covered in the 1959 annual report. These 4 numbers contained 55 technical articles, 4 phytopathological notes, one obituary, abstracts of the 1959 annual meeting (24 pages), the index (22 pages), errata (1 page), and the table of contents (11 pages). Volume 49, the largest published so far, contained 832 pages.

The number of manuscripts submitted increased sharply in 1959—260, compared to 202 in 1958. The rate of submission continues relatively high. The number received during the first 6 months of 1960 was 121, compared to 108 and 147 for the same months of 1958 and 1959, respectively. When it is considered that, for the 7 years prior to 1959, an average volume of PHYTOPATHOLOGY contained only 168 technical articles and phytopathological notes, it is clear that we could not have kept up with the flow of manuscripts had we not materially increased the size of the volume. Enlarging about half the numbers of Volume 49 by 16 pages permitted us to publish 197 manuscripts in 1959. Most of the 1960 numbers of the journal are being increased by 16 or 32 pages. Volume 50, consequently, will be as large as Volume 49, or larger. As this report is being written (July 12-15), 6 numbers of Volume 50 have been published, the seventh is in press, and the eighth is in the paste-up stage. These 8 numbers contain 626 pages with 148 articles and notes, compared to an average of 464 pages with 112 articles and notes for the first 8 numbers of Volumes 42-48. Even this rate of publication (18.5 manuscripts per month) is below the current rate of manuscript receipt (20 per month).

Authors often inquire about the length of time required to publish an article in PHYTOPATHOLOGY. The date of acceptance, appearing on each published technical article, is the date on which the revised manuscript is returned to the editorial office by the author. Articles in the May, 1960, number, for example, were accepted for publication between November 23, 1959, and January 11, 1960. This number was issued on May 17, the average number of days between acceptance and publication being 153. The average manuscript in this number, however, was received 80 days before the date of acceptance. Thirty-seven of the 80 days were required for review and editing and 43 were required for revision by the author.

Some changes in style were initiated in 1960. We are asking that footnotes be avoided so far as possible, the necessary information being given in the text. Author's title, credit lines, and date of acceptance are now placed just before the summary and are not referred to by footnote numbers. The principal section headings appear in bold-faced type and literature citations always appear at the end of the article. Phytopathological notes follow the style of technical articles, except that no summary or section headings are given. The titles of abstracts are in bold-faced type instead of italics. Authors are urged to read the instructions on "Writing for PHYTOPATHOLOGY" which appear on the second page of each issue of the journal.

This is the last year of my editorship. I wish to thank the Editors, the Business Manager, members of the Council, and the Printer, Mr. John Ferguson III, for the kind of support and cooperation so necessary to effective operation of an editorial office. I particularly wish to thank Mr. Kelvin Deming, who has shown himself to be an outstanding scientific editor. The Society is indebted to him for services volunteered beyond the scope of his regular duties. It was he who overhauled the physical style of PHYTOPATHOLOGY, mentioned above, and revised the style of indexing, using three type faces, to make its use easier.

E. E. Wilson

Report of the Advertising Manager. During the fiscal year that ended on June 30, 1960, 59 pages of paid ads, 9 pages of News, and 11 pages of free ads were published in PHYTOPATHOLOGY. Eighteen advertisers who had previously advertised in PHYTOPATHOLOGY and 26 prospective new clients were solicited in 1959. Of these, 12 former advertisers and 1 new client contracted for space in Volume 50. The assistance of the Editor-in-Chief, the Business Manager, the Printer, and their staffs, is sincerely appreciated.

D. A. Roberts

Report of the APS Representative, AAAS Council. Most of the time at the AAAS Council meeting was taken up in vigorous debate on the recommendations of the Committee on Council Activities and Organization. This Committee, hoping that the Council could be made into a better informed and more active body, had recommended: (1) a permanent Committee on Council Activities and Organization to serve as a steering committee for the Council; (2) a permanent Committee on Constitution and Bylaws; (3) a number of study committees to report to the Council on special topics; (4) a set of rules for Council operations; and (5) further study of the methods of selecting Council members and several other problems.

The final result of the long debate was approval by the Council of all of these proposals except Item (1), the proposal that there be a standing Committee on Council Activities and Organization. Its functions were not as precisely described as they might have been, and many members feared that there would be confusion and overlap of responsibilities between the Committee on Council Activities and Organization and the Board of Directors. The Council therefore rejected the proposed standing Committee on Council Activities and Organization, but did continue the ad hoc committee of that name for a second year.

The new Chairman for Section O, AAAS, is Firman E. Bear.

H. A. Rodenhiser

Report of the APS Representative, AIBS Board of Directors. The members of the American Phytopathological Society may rest assured that the money expended for membership in the AIBS is one of the better, if not the best, investments of the Society. The organization is under dynamic leadership and is doing

a tremendous job in furthering the interests of all biologists.

The AIBS membership paid only $31,866.15 during the year ending December 31, 1959. This was used to support an operational budget of $109,731.14. The deficit was more than covered by earnings of the staff in the form of $94,913.77 as overhead from contracts and grants. The AIBS Bulletin imposed a deficit of $15,384.24 on the budget, and the Placement Registration a deficit of $1,442.50. The net income was $21,757.74 in a net worth of $128,218, most of which is in the form of accounts receivable ($96,817.50). So-called total accrual of excess income at the year's end was $30,936.41.

The auxiliary activities of the Institute in promoting biology through grants are phenomenal. Thirty-three contracts in force with the National Science Foundation and other foundations provided $1,224,242 income aside from the general operational expenses in 1959. The annual convention was operated so it was self-supporting, the Quarterly Review of Biology was regenerated so it earned $6,378.57, and the Symposia proceedings earned $3,570.24.

The central office activities were considerably expanded, and excellent new quarters were obtained on a very satisfactory rental basis. The redactory and other publication services were further developed and are available to member societies without adequate editorial staffs.

Among the projects supported by grants, your representative has been tremendously impressed by the efforts on behalf of primary and secondary education in biology. A series of 120 motion pictures for illustrating various aspects of biology for high school teaching is rapidly being developed. The biological sciences curriculum study committee under Dr. Arnold Grobman of the Florida State Museum, now on leave for full-time guidance of this project at the University of Colorado, has developed an outline. There will be writing sessions of biologists and high school teachers to develop a preliminary text this summer. It will be tested out scientifically in 105 high schools located in 15 centers througout the United States. The progress of the group of seven teachers at each center location will be carefully appraised in a conference seminar under a university professor each week. Their conclusions will be collated at the center in Colorado and the group will reconvene in the summer of 1961 to compose a final version of a textbook.

The visiting lectures programs for smaller colleges and high schools were tremendously successful again in 1959. The AIBS translation services are now translating six Soviet journals into English, and translation of monographs is well under way.

The AIBS Board of Governors held two meetings under the presidency of phytopathologist James Dickson of the University of Wisconsin: at Pennsylvania State University, August 29, 1959, and at the University of Colorado on May 12 and 13, 1960. Future sites of meetings will be: 1960, Oklahoma. 1961, Purdue University; 1962, Oregon State; 1963, Massachusetts; and 1964, Colorado.

Recommendations: (1) Our complete support of this dynamic organization with full recognition that dues are woefully inadequate and will have to be raised some time in the future. The $1,000 maximum per society has been deleted after prolonged debate so all groups are contributing on all members at present.

(2) Our Editorial Committee should maintain liaison with Mr. Harwood regarding use of their radactory services. He has ideas and a couple of decades of experience in publishing which we could use. The Entomology Society and Phi Sigma Society already are subscribers.

(3) There is being developed a Biological Resources Textbook of experiments for gifted high school students to supplement routine laboratory exercises. This is being done at the University of Texas under the guidance of a committee chaired by Dr. H. Bentley Glass of Johns Hopkins University. I recommend a committee or subcommittee of the teaching committee be formed by APS to develop suitable outlines and submit them for test. This is a gorgeous opportunity to get the attention of high school students directed toward plant diseases and there are hundreds of simple experiments we can propose. The University of Texas staff will try each of these out in their own lab and rewrite directions as to use before putting the projects in their manual. They need ideas involving simple techniques with readily available materials.

GEORGE L. MCNEW

Report of the APS Representative, Agricultural Research Institute. Through the efforts of the Agricultural Research Institute, the Agricultural Board has received from the Rockefeller Foundation a three-year grant totaling $50,000 for studies of factors affecting national policy and planning in agricultural research. Consideration is being given to the establishment of a steering committee, employment of a project chairman, and possible sources of additional financial support for this broad study.

The Agricultural Research Institute passed a resolution favoring expansion of agricultural production research and increased financial support for basic research needed to make agricultural production more efficient and agricultural products more effectively distributed, marketed, and used. Copies of this resolution were to be sent to the Secretary of Agriculture, the Administrator of Agricultural Research Service, and both the Senate and House Agricultural Committees, presidents of all Land-Grant Colleges and Universities, and others.

The Committee on Agricultural Meteorology and Climatology is preparing a text for this field to promote recommendations having practical application to agriculture and the application of basic principles underlying plant and animal response to climatic factors. Consideration also is being given to holding a symposium in the near future.

The Committee on Agricultural Pests has been

active in stimulating interest among research workers in accumulating and publishing data on losses from various pests, and relationships between biological control and economics of crop and livestock production. These activities will be continued with the support of a renewal grant from the Rockefeller Foundation amounting to $9,500 per year.

F. L. LeClerg
C. L. Lefebvre

Report of the APS Representative, Division of Biology and Agriculture, National Research Council. The APS should take the lead in bringing the Division and the Society together more closely by selecting the most appropriate of a number of suggested problems and presenting it as a concrete proposal for action. This can be done either through me or directly; it makes no difference. Sample topics which have been called to my attention this past year are: (1) means to increase the number and attractiveness of prizes and awards in the biological sciences; (2) the matter of paid vs. volunteer help in all phases of journal preparation; (3) how best to accomplish the "business" of a large society, i.e., by unpaid elective officials on the one hand and by an executive secretary on the other; (4) promotion of additional conferences similar to that projected for 1961 on Biological Control of Soil-borne Plant Pathogens; (5) adequate measures for presenting the profession of pathology to the public and for introducing its viewpoint into teaching at the high school, including the possibility of a new Society publication aimed at this market. I suggest that the Council select one of these problems, or another deemed more appropriate, formulate a tentative plan of action, and present it to the Division with a request for consideration and implementation.

The annual meeting for the National Research Council followed a pattern established two years ago, convening as a single body for most of the time. Symposia were held on "Dynamics of Natural Resources," "Grants and Fellowships as Factors in the Development of Scientists," and "Transportation and Patterns of Living." Division meetings and dinners took place in the afternoon and evening of March 25, and a final plenary session of the Research Council was scheduled for Saturday morning.

The sourcebook of laboratory exercises in high school biology is being published this summer by the Holt firm, and the Handbook of Biological Data has been transferred to the so-called Federation. The role of the Division in education is still under consideration, and it might be well for the Council to express its views on the matter at this time.

Somewhat more immediately pertinent to plant pathology was a special conference on pesticides and wildlife, held January 15, to which your Division representative was invited as an observer. From this discussion there has emerged a divisional committee on pest control and wildlife relationships under the chairmanship of Dr. Ira L. Baldwin of the University of Wisconsin. It is my impression that plant pathologists will need to make their wishes known if they care to have this committee consider fungicides and related materials along with those more strictly insecticidal. Of somewhat similar concern is a movement within the ARI-Ag. Board to arrange a symposium on the role of chemicals in food production, although I now understand that the tentative date for such a meeting has been set off until after 1960.

Miscellaneous items of interest to our Society are as follows, with comments as appropriate:

1) Your representative served for a second year as the chairman of the divisional committee reviewing applications for NSF postdoctoral fellowships. There were all too few from the agricultural sciences and from plant pathology in particular. We owe it to our very good students to urge their application, and to stress the importance of submitting a plan of study which emphasizes their personal growth as scientists. Many applicants drop out of the final competition because they clearly look upon these fellowships as research grants, which is entirely aside from what the NSF expects and directs the selection committee to consider. We can take comfort in the fact, however, that awards are made on merit alone.

2) Several members of our Society responded through me to the NAS-NRC request for applicants to become Deputy Scientific Attaches in five overseas posts, and for persons interested in the exchange visits arrangements with the Soviet Union. We replied, through our President, to an inquiry concerning attendance of Soviet scientists at our annual and other meetings, and are represented at the top post by Dr. Harrar in the NAS-NRC Latin American exchange program.

3) The Division of Biology and Agriculture acted as administrative agent for a number of granting agencies in screening applicants for travel grants to a series of four international conferences being held this summer —in photobiology, histochemistry, cell biology, and embryology.

4) Just recently the Division held a special meeting on problems in tropical botany, chaired by Dr. Robbins, in Florida. I do not know, at this writing, whether or not this included tropical agriculture. If not, we should perhaps urge that any future activity be expanded to this area.

The Council should move in support of strengthening the non-applied aspects of biology. It would be a very fine thing for one of the affiliated societies, particularly one often accused of over-emphasis on practical matters, to spearhead the formation in the Division of a board or council comparable with the Agricultural Board to concern itself with, if you will, non-applied aspects of biology. The APS has an enviable record in promoting the firm establishment of the American Institute of Biological Sciences. It could add another laurel by taking the lead in re-establishing a Biology Council or its equivalent in the NAS-NRC Division, and thus demonstrate to itself and to outsiders that plant pathologists are first and foremost scientists with a concern for biology as a whole.

Russell B. Stevens

Report of the APS Representative, Food Protection Committee, Food and Nutrition Board, NAS-NRC. The 9th Annual Meeting of the Liaison Panel of the Food Protection Committee, held in Washington, D. C., December 9-10, 1959, was devoted to a symposium on special problems in the toxicology of food additives. While the primary concern of the meeting was on intentional food additives, the impact of the recent unintentional additive to the cranberry crop received considerable notice.

Mention was made of various sources of toxicological data. One important source is the effect of food additives on individuals who are occupationally exposed during the manufacture and processing stages. This is reported by the highly organized industrial medicine group.

A comparable source, that of observations by plant pathologists of unsuspected toxic effects on those using pesticides, has not been fully utilized.

Two publications of the Committee which may be of interest are NAS-NRC Publication 749, "Problems in the Evaluation of Carcinogenic Hazard from Use of Food Additives," and Publication 750, "Principles and Procedures for Evaluating the Safety of Food Additives."

J. R. McGrew

Report of the APS Representative, Board of Editors, American Journal of Botany. Communication with the Editor of the American Journal of Botany was re-established during this past year, an indication that the appointment of a representative should be continued.

A. F. Ross

Report of the APS Representative, American Type Culture Collection. The annual meeting of the American Type Culture Collection was held at the Collection headquarters in Washington, December 11 and 12, 1959. The Curator and Assistant Curator reported a satisfactory year in all respects: 869 cultures have been added to the collections since the last edition of the catalogue was issued, for a present total of 5,356, about equally divided between fungi and bacteria. There have also been substantial increases in the plant and animal viruses which are catalogued separately. Total receipts for 1959 were $94,523 and expenditures $84,937. Receipts included $80,183 from sale of cultures, $8,247 from grants, $4,302 from cultures deposited as a basis for patents, and the remainder from interest on investments and miscellaneous sources. The total worth of the corporation exceeds $146,000, including securities held as investment, cash on hand, and equity in the headquarters building. Revised catalogues of the viral and Rickettsial specimens and of the plant viruses available for sale were issued during the year.

The Board of Trustees approved a budget of $302,215 for 1960. Included in this amount are the sums to be received in connection with four grants from the National Institutes of Health. These are (1) continuation of the virus and Rickettsia register, $5,000; (2) taxonomic studies in bacteriology, $15,250; (3) continuation of bacteriophage research, $10,500; (4) tumor virus, tissue culture repository, $192,680. In addition, the National Institutes of Health has made a tentative grant of $90,000 to aid in setting up more adequate facilities for the Collection. The Board of Trustees appointed a building committee to plan actively for an adequate building for the Collection in the light of its increased responsibilities and obtain the necessary funds. As part of the planning, consideration is being given to possibilities of adding facilities for a virus and fungus identification service.

Dr. Freeman Weiss retired as Curator effective December 31. He was succeeded by Dr. William A. Clark, formerly Assistant Curator, who was named Director. Dr. Weiss was appointed Curator Emeritus, and will continue to act in an advisory capacity.

John A. Stevenson

Report of the APS Representative, Research and Development Associates, Food and Container Institute. The Army has announced plans to construct a research facility geared directly to the needs of its revised program to speed irradiated food research. The facility will consist of a million curie cobalt-60 irradiator and a variable energy electron source. Its location has not yet been determined, but according to present plans, it will be operational in about two years and will be made available for use of other agencies working in the field.

Working through a contract with the Quartermaster's Food Preservation Project, your representative and his associates have continued studies in this laboratory on the control of post harvest diseases of fresh fruits and vegetables by means of gamma radiation.

M. A. Smith

Report of the APS Representative, Biological Stain Commission. The Biological Stain Commission has recently prepared an exhibit giving an account of its past history and present activities and services. Accompanying the exhibit are brochures for distribution. It has been displayed at the national meetings of some of our sister societies in the AAAS and could well be used at meetings of the APS.

The recommendations of the Biological Stain Commission that "certified stains be used in precise techniques and that the certification numbers be cited," have been generally accepted and used by certain authors in PHYTOPATHOLOGY. With the ever increasing import of stains and related chemicals that are different, but bear the same name of certified stains, it cannot be over-emphasized that only well-defined stains meeting standard specifications can be relied upon as standard tools in research as well as uniform routine laboratory practices. Precise staining procedures, in order to be valid, demand that an author employ a specified stain to which others have recourse. It must be reliably identified, purified, tested, and therefore, found capable of being duplicated.

To acquaint phytopathologists with those 57 stains

currently certified by the Biological Stain Commission, they are listed below:

Alizarin red S	Malachite green
Aniline blue WS	Martius yellow
Auramine O	Methyl green
Azocarmine G	Methyl orange
Azure A, B and C	Methyl violet 2 B
Bismarck brown Y	Methylene blue
Brilliant cresyl blue	Methylene blue thiocyanate
Brilliant green	(tablets)
Carmine	Methylene violet
Chlorazole black E	Neutral red
Congo red	Nigrosin
Cresyl violet acetate	Nile blue A
Crystal violet	Orange G
Darrow red	Orange II
Eosin B	Orcein
Eosin Y	Phloxine B
Erythrosin	Pyronin B
Ethyl eosin	Pyronin Y
Fast green FCF	Resazurin (tablets)
Fuchsin, acid	Rose Bengal
Fuchsin, basic	Safranin O
Fuchsin, basic	Sudan III
(special for flagella)	Sudan IV
Giemsa stain	Sudan black B
Hematoxylin	Tetrachrome stain
Indigo carmine	(*MacNeal*)
Janus green B	Thionin
Jenner's stain	Toludine blue O
Light green	Wright's stain

It is well to remember that the services of the Stain Commission are available should problems arise when using certified stains.

SHIRL O. GRAHAM

Report of the APS Representative, American Standards Association Sectional Committee on Common Names for Pest Control Chemicals, K62. An additional seven new common names are now being considered by the Committee. These include six herbicides and one fungicide. A second, third, and fourth list of common names proposed by the International Committee on Common Names for Pesticides ISO/TG81 were reviewed by the members of ASA Sectional Committee K62. Continued representation by the Society on ASA Sectional Committee K62 is recommended.

S. E. A. MCCALLAN
W. D. MCCLELLAN, Alternate

Report of the APS Representative, American Grassland Council. One of the principal objectives of the American Grassland Council is the dissemination of information on new developments in the production, preservation, and utilization of grassland crops. A highlight of the past year was the introduction of a quarterly publication, *Grassland Progress*. This new publication presents, in abbreviated form, the broad aspects of progress in grassland agriculture. It includes research reports, accounts of successful applications of the results of research, notices of relevant meetings, conferences, and new books, and other information pertinent to grassland farming.

The AGC held its annual business meeting in conjunction with the national meetings of the American Society of Agronomy at Cincinnati, Ohio, November 19, 1959. Progress reports on the status of the revision of the "Grassland-Livestock Handbook" and on the construction of the new "Educational Exhibit" were made.

Several Council members attended the AAAS meetings at Chicago, Illinois, December 28-31, 1959, to hear and participate in the symposium program on "Germ Plasm Resources for Agriculture; Development and Protection." The American Society of Range Management met at Portland, Oregon, February 2-5, 1960. The AGC held its 1960 annual meeting at Ohio State University, June 14-16. This meeting included tours, paper sessions, and inspection of research in progress at Columbus and Wooster. It was sponsored jointly by the AGC and the American Society of Agricultural Engineers.

The 17th Biennial Alfalfa Improvement Conference was held at the University of Saskatchewan, Saskatoon, Saskatchewan, Canada, June 27-29, 1960. The program included papers on diseases and harmful insects.

The 8th International Grassland Congress was held at Reading, Berkshire, England, July 11-21, 1960, to encourage the exchange of information among scientists working on grassland problems. Papers in the agronomy section were concerned with plant breeding, seed production, appraisal of species, herbage physiology, minerals in plant nutrition, nitrogen fertilizers, herbage diseases and pests, forage in difficult environments, tropical grasslands, improvement of permanent pastures, and irrigation. Dr. K. W. Kreitlow of the Agricultural Research Service, USDA, and Dr. W. H. Sill, Jr. of the Department of Botany and Plant Pathology, Kansas State College, were official representatives of APS at this meeting. Dr. Kreitlow served as chairman of the Herbage Disease Section.

Membership in the American Grassland Council is open to anyone interested in any phase of grassland activities. Its membership exceeds 200.

E. W. HANSON

Report of the APS Committee on Extension. Our Committee met formally this year on September 1, 1959, at State College, Pennsylvania, during the American Phytopathological Society annual meeting.

The Committee sponsored an informal Extension-Industry breakfast at the 1959 meeting which was well attended by 22 Extension and research and 24 Industry men. The Committee also sponsored a two-hour symposium at the meetings on Extension methods and techniques with emphasis on problems relating to servicing the growing numbers of urban-suburban constituents.

The slide-set project is a continuing one due to unusually great interest over the world. The initial supply of 626 sets of the seven series was exhausted in September, 1959. After many back orders had accumulated, the decision was made to re-run a smaller number of all sets. This was accomplished in May, 1960, and their reavailability was made known by letter. To date, 108 additional sets have been sold, leaving 111 sets available for future orders. Perhaps in the

years ahead additional subjects will be prepared and offered.

The color publication project has progressed to a point where it would appear that low price 4" x 5" four-color photos on enamel paper may be available for the modest price of $16.50 per thousand if states with mutual disease problems will pool orders with a minimum of 50,000 for each subject. The north-central Extension Pathologists section has a subcommittee investigating color costs also. Their efforts will be coordinated with those of the Committee. The future looks bright for low cost color if full cooperation is achieved among the states.

An effort is being made to organize Extension workers' groups within the five sections of our Society in order to permit closer cooperation on projects and events of mutual interest to Extension pathologists.

ARDEN F. SHERF, Chairman

Report of the Committee on Finances and Investments. The book value of the invested funds of the American Phytopathological Society at the close of the fiscal year, June 30, 1960, amounted to $134,254.42, distributed as indicated in the accompanying summary. A complete list of our holdings is part of the report of the Treasurer and Business Manager. Earnings (interest and dividends) amounted to $5,028.95, and $15.96 in capital gains distribution was accepted in cash. In addition, $230.40 in capital gains distribution was accepted as 16 shares of Wellington Fund, $355.96 as 22 shares of Boston Fund. On February 8, $5,000 was withdrawn from Southern Federal Savings and Loan and from California Federal Savings and Loan for general expenses and to purchase additional shares of Boston Fund.

A. W. DIMOCK, Chairman, ex-officio

Report of the Standing Committee on History of Plant Pathology. A few miscellaneous items were added to the Society's historical file during the year. Major attention was given, however, to preparing a plan for the future operation of this activity. This plan was submitted in March to Dr. William C. Snyder, President of the Society. It recommended the permanent deposit of all materials assembled by this Committee with some interested Plant Pathology Department and the appointment of an Archivist, as an official of the Society, to be responsible for gathering new materials and their maintenance.

JOHN A. STEVENSON, Chairman

Report of the Committee on International Cooperation. This Committee has brought to conclusion some years of work to develop a Caribbean Division of the American Phytopathological Society. Several conferences attended and letters exchanged resulted in a final decision to start such a Division. A President and Corresponding Secretary were named; the first meeting of our Division will be held in 1961.

This first meeting will be held in association with the Caribbean Section of the American Society of Horticultural Sciences in Miami, Florida, the week before or after Easter, 1961. It has been suggested that the pathologists and horticulturists work together on their meetings. Some years they will be held separately, but in countries with sufficiently ample facilities, it is hoped that they can be handled together.

The Committee on International Cooperation is planning a symposium on Tropical Plant Pathology, to be given at the regular meeting of the Society in Biloxi, Mississippi, in December, 1961. In a measure the symposium will cover the subject world-wide, includ-

SUMMARY OF INVESTMENTS

	Original Investment	Value 1/30/60	% Total	Earnings 1959-60
Cash or equivalent:				
Ins. Sav. & Loan Passbook*	$	$ 63,469.21	47	$2,772.20
Ins. Sav. & Loan Certificate*	10,000.00	10,000.00	7	410.00
Savings Accounts, local		6,366.83	5	133.08
U. S. Savings Bonds	2,193.50	2,358.65	2	82.43
		$ 82,194.69	61	$3,397.81
Securities:				
Common Stocks	$22,075.13	$ 34,385.31	26	$1,170.10
Investment Funds				
Previous holdings	14,992.20[a]			
Capital gains dist. 1959	586.36	17,673.42[b]	13	477.10[c]
Purchased March 1960	3,639.30[a]			
		$ 52,059.73	39	$1,647.10
TOTALS		$134,254.42		$5,044.91

Irregular deposits and withdrawals preclude realistic statement of original investment.

[a] *Includes 7½ to 8% brokerage fee.*

[b] *Full cash value, no brokerage fee.*

[c] *Includes $15.96 capital gains not converted to stock.*

Transactions for the past fiscal year:

1. *Westinghouse Electric split 2 for 1, increasing our holdings from 57 to 114 shares.*
2. *Interest and dividends allowed to accrue in savings accounts.*
3. *Purchased 210 shares of Boston Fund at $17.33.*

ing not only generalities but also condensed reviews by specialists on diseases of important tropical crops.

FREDERICK L. WELLMAN, Chairman

Report of the Committee on Phytopathological Classics. During the period covered by this report, a reprinting was made of Phytopathological Classic 3, "The Discovery of Bordeaux Mixture" by Millardet. During the coming period, it will probably be necessary to reprint Phytopathological Classic 4, "*Plasmodiophora brassicae*, the Cause of Cabbage Hernia" by Woronin.

A list of titles in the Phytopathological Classics series that are currently available is given in the December, 1959, issue of PHYTOPATHOLOGY.

The report of the Treasurer of PHYTOPATHOLOGICAL CLASSICS, Dr. Robert S. Dickey, for the fiscal year July 1, 1959 through June 30, 1960, shows a cash balance on hand of $1,232.50.

The number of copies of PHYTOPATHOLOGICAL CLASSICS sold during the fiscal year was 197, having a total value of $224. Numbers of Classics on hand at Ithaca, New York, and at Lake Alfred, Florida, on June 30, 1960, were as follows: No. 1, 405; No. 2, 425; No. 3, 0; No. 4, 32; No. 5, 262; No. 6, 312; No. 7, 237; No. 8, 425; No. 9, 613; and No. 10, 821.

L. C. KNORR, Chairman

Report of the Committee on Phytopathological Monographs. The Committee on Phytopathological Monographs requested and received from Council an official statement of policy concerning the proposed monograph series authorized by previous Council action (PHYTOPATHOLOGY 47:320, 1957). This statement provides the Committee with tangible authority for a positive approach to the solicitation of monograph manuscripts. It deals briefly with the purpose of the monograph series and the various aspects of preparing, financing, and publishing monograph manuscripts, and is available for distribution in ditto form.

One monograph manuscript has been received and is now in review. If accepted, it is expected that this manuscript will be processed for publication within the year.

Progress reports were solicited and received from 13 prospective authors who had previously made tentative commitments to produce monograph manuscripts. Eleven of these commitments were confirmed and two were withdrawn. Seven authors estimated completion dates falling within the next three years. Two of these are scheduled for completion in 1961, three in 1962, and two in 1963. Completion dates for the remainder are indefinite.

C. S. HOLTON, Chairman

Report of the Committee on Phytopathological News Page. During 1960, alternate half and full pages of news have been or will be published in each issue of the Journal. For able assistance in preparing the news page in 1960, the Editor wishes to acknowledge his appreciation to the members of the Standing Committee: Spencer H. Davis, D. E. Ellis, Shirl O. Graham, W. E. Sackston, L. O. Weaver, and Roy D. Wilcoxson.

K. W. KREITLOW, Editor

Report of the Committee on Phytopathological Reviews. The Committee on Phytopathological Reviews can report enthusiastically on the completion and publication of the mammoth job of "Bibliography of Reviews" by a member and former Chairman, Dr. Russell B. Stevens. This publication should be of high value to those who work at the problem of synthesizing the fragments of plant pathology into workable units.

In last year's report the Chairman mentioned several reviews that had been contracted for. The output has fallen below expectations. Only Dr. Ellen L. Moorhead has completed her commitment for a review on the "Status of Plant Virus Serology." This leaves five others unaccounted for.

Clearly, to obtain reviews for PHYTOPATHOLOGY is a difficult task under the present system. The former Chairman worked hard on the problem, solicited six reviews over a two-year period and got one delivered after about a three-year lag.

The Chairman on behalf of the ANNUAL REVIEWS group has solicited the thoughts of 100 members of the Society at random on the prospects of publishing an "ANNUAL REVIEW OF PLANT PATHOLOGY." The returns split just about 50-50 on the question of desirability. Most of the 50 nays say that the profession does not need such a review journal.

This is an astonishing anomaly when it is considered in the light of the high interest in symposia and in the publication of the proceedings. In effect this is a system of reviews. Why the feet dragging on review articles? Presumably a review *per se* is a lesser status symbol than a symposium paper. The very word "review" has acquired a connotation of an annotated bibliography that is not a very high class piece of scientific work. Many consider that it is mundane and unexciting.

The Committee suggests, (1) that the Society does need frequent critical appraisals of the various segments of our science; (2) that these appraisals should point out gaps in our knowledge; (3) that they should suggest experiments to fill the gaps; (4) that they should speculate on the broad significance of detailed advances in knowledge; and, thus (5) that these appraisals should develop new knowledge by synthesizing the fragments of information available into workable and understandable units of the science of plant pathology.

The Committee further feels that the word "review" does not usually connote these concepts to most plant pathologists. That being so, we need a new word or phrase for the Committee name. The following possibilities occur to us: appraisal paper, critique, treatise, advanced thesis, assay paper.

Finally, the Committee questions the need for two committees—Monograph and Review. We strongly urge the Council to combine these.

JAMES G. HORSFALL, Chairman

Report of the Committee on Placement. The American Phytopathological Society's Placement Committee had a total of 70 applications in the active file during the past year. A study of application dates shows that 21 were filed over 2 years ago and 49 during the past 2 years. Of these, 3 and 21, respectively, accepted new employment and withdrew their records from the active file, and 3 and 1, respectively, withdrew their records for other reasons; an additional 2 and 8, respectively, accepted new employment but retained their applications on an active basis. This leaves 15 of the older and 27 of the more recent applications, or a total of 42 applications in the active file. Although training, productivity, recommendations, nationality, etc., are important factors in placement, out-of-date records no doubt become a limiting factor. This is being corrected by having new applications submitted.

Employers were contacted regarding 53 positions and 240 application records were submitted for 42 of these positions. It is known that 28 of these have been filled, at least 6 by Placement Committee contacts. So far as is known, the other positions are still pending or have been discontinued.

In addition to routine contacts by mail, a number of personal introductions were made at the Pennsylvania State University meetings in cooperation with the AIBS Placement Services. Results of these personal interviews are not known as adequate records are not kept.

To encourage more extensive use of the Placement Committee, a letter was sent to 48 departmental heads requesting that they (1) urge more of their graduate students to register with the Placement Committee, and (2) notify the Placement Committee Chairman, giving a brief job description, when there are openings on their own staffs. This latter procedure eliminates the time lost by an exchange of letters when the Committee learns of the opening through the normal routes. Although the response to the above letter was not overwhelming, it was encouraging.

Persons interested in Federal positions should fill out Standard Form 57 and mail it to the Executive Secretary, Board of U. S. Civil Service Examiners, Sixth Floor, Administration Building, U. S. Department of Agriculture, Washington 25, D. C. There is, on most Land Grant College campuses, an Agricultural Research Service Contact Representative who can supply additional information or forms.

It is the responsibility of the applicants to keep the Committee informed of changes in address or employment status. If there is no reply after three attempts to contact the applicant, his application is placed in the inactive files. All records and files are currently up-to-date.

W. E. COOPER, Chairman

Report of the Committee on Public Relations. Last year we inserted in a handbook sponsored by Science Service and sent to high schools throughout the United States an announcement of the availability of our brochure, "Careers in Plant Pathology." As a result, about 4,000 science clubs have requested copies. At the time of the cranberry crisis, our Committee regularly supplied pertinent information to the press, which helped to offset some of the severe criticism of the use of chemicals to control diseases. We have continued along the lines initiated six years ago of publicizing some of the outstanding plant disease research papers. Selected material appearing in PHYTOPATHOLOGY has been used in advance through the cooperation of the Editor-in-Chief who made galleys available before publication. Press releases for about 40 contributed papers that seem to have publicity value will be issued at the time of presentation at Green Lake.

The Committee and Society efforts during the past four or five years have been directed primarily into publicity channels. In addition to the brochure, the motion picture, and other educational presentations, efforts were made to get favorable information about the Society and the science into newspapers and magazines and on radio and TV. This has been done primarily through stimulating individual effort on the part of Society members, and also through part-time professional assistance. The latter assistance has been largely responsible for publicizing national meetings and interpreting research papers for the popular press. Publicity for the Society could be expanded by a greater consciousness of the need for public relations and by a concerted effort on the part of the members. Society members represent government, universities, foundations, and industries, most of which have professional information or publicity offices. An aggressive public relations drive, developed as a Society program, could make profitable use of these offices. It would give rise to locally originated information of regional or limited interest. In other words, the Society, through its membership, is in a good position to publicize at the grass-roots level.

Our Committee has recommended to the Council that it consider increasing the responsibilities and activities of the Public Relations Committee and perhaps secure the services of a professional Public Relations Consultant.

PAUL R. MILLER, Chairman

Report of the Committee on Regulatory Work and Foreign Plant Diseases. The Committee met during the year in two sessions, at the Pennsylvania State University, University Park, Pennsylvania, during the 51st annual meeting of the Society. The first session was held on Sunday afternoon, August 30, and the second on Tuesday evening, September 1, 1959.

R. P. Kahn presented a progress report for the period of August, 1958, to August, 1959, on his work having to do with the virus indexing of imported plants and plant propagating materials at the USDA Plant Introduction Station, Glenn Dale, Maryland, particu-

larly with reference to the indexing of imported *Prunus* species, and on the supporting research he is carrying on there. He also presented and discussed a proposed policy for governing the release of imported *Prunus* species currently in quarantine at the USDA Plant Introduction Station at Glenn Dale, Maryland, and expected to be released at the completion of the virus indexing tests.

Committee Member E. G. Rex reported on the assignment given him at last year's committee meeting to explore the possible means of accomplishing exploratory tests to determine what plant pathogens are coming into the United States on imported seeds. The Committee and the Society previously had recommended laboratory examination of such seeds as an inspection procedure (PHYTOPATHOLOGY 50:252-253, 1960). Rex reported that the USDA Plant Quarantine Division would investigate the problem in its facilities at Hoboken, New Jersey, in collaboration with Paul Neergaard of Denmark, who was sponsoring an international seed testing program and who had met with our Committee in August, 1958, at the Bloomington, Indiana, meetings.

H. S. Dean, Assistant Director of the USDA Plant Quarantine Division, reviewed and reported on the new federal plant pest act of 1957 and the regulations for enforcing it. The responsibilities of the research workers to apply for permits for importation and interstate movement of plant pathogens, and of the Division Director in acting on applications for permits, were reviewed in some detail. It was emphasized that the enforcement of the regulations usually would not prove to be a handicap to responsible research. The cooperation of phytopathologists was requested in aiding this effort to prevent plant pest spread.

G. L. Stout discussed the European rhododendron rust (*Chrysomyxa ledi* var. *rhododendri*) problem and reviewed the current information on the situation regarding this rust in California and the Pacific Northwest (Oregon, Washington, and British Columbia). He reported that this rust problem was discussed at the National Plant Board meetings in Portland, Oregon, in September, 1958, which he attended, and that the consensus there was that surveys for the rust should be extended. Surveys made by state and county departments of agriculture in California during 1959 covered 139 locations in 16 counties and disclosed the presence of the rust at six locations (on six properties and in four counties) in California coastal areas from San Francisco north, on cultivated rhododendrons but not on wild rhododendrons. Another rust species (*Chrysomyxa piperiana*) occurs commonly on cultivated and wild rhododendrons in the same areas in California and is known in California, Oregon, Washington, and British Columbia. The two rusts can be distinguished from each other by microscopic examination of the uredospores, but not by visual inspection. Both rusts can occur on the same leaf. These factors make detection of the European species difficult. Eradication is difficult because of the problem of detecting all of the infections. However, suppression is being attempted by defoliation of infected plants and by the application of fungicides.

E. C. Blodgett discussed the K and S virus (Kwanzan & Shirofugen latent virus) situation in relation to the propagation of Kwanzan and Shirofugen flowering cherries. There are no known sources of Shirofugen and perhaps only one source of Kwanzan free of this virus, which appears to be identical with the virus causing the very destructive little cherry disease of the Kootenay area of British Columbia.

Eugene B. Hayden of the Rust Prevention Association, 820 Midland Bank Building, Minneapolis, Minnesota, discussed the effects of the opening of the new St. Lawrence waterway and increased air and rail traffic on the problem of plant disease detection at United States ports of entry. He indicated that the volume of traffic had increased at a much higher rate than expansion of plant quarantine facilities at the ports, and that there is a resulting increase in pest hazard against which protection is needed.

The following resolution was presented by the Committee to the Council:

"The possible introduction of foreign plant diseases into the United States by a growing volume of international traffic is a constant threat to American agriculture. Traffic at U. S. ports of entry has been greatly increased by the recent opening of the St. Lawrence waterway. We urge that additional federal funds be made available to the Plant Quarantine Division to insure adequate inspections in order to guard against the introduction of destructive plant diseases."

This was approved by the Council and by the Society.

In a letter dated September 21, 1959, APS Secretary William B. Hewitt transmitted to Secretary of Agriculture Ezra Taft Benson, in resolution form, the essence of the Committee's recommendation, and on October 2, 1959, W. L. Popham, Acting Deputy Administrator of the Agricultural Research Service, U. S. Department of Agriculture, acknowledged Secretary Hewitt's letter, thanked him for it, and stated, "We appreciate the interest the Society has taken in this problem which has also been of serious concern to us. You may be assured that the need for strengthening port-of-entry inspection is being taken into account in our future planning."

The Chairman wishes to express his appreciation to the other members of the Committee for their participation and collaboration in the committee work, and to the Council and the Society for their support.

GILBERT L. STOUT, Chairman

Report of the Committee on Seed and Plant Material Certification. The Committee on Seed and Plant Material Certification met at the Annual Meeting of the Society held at Pennsylvania State University in August, 1959. Agreement was reached to continue the Committee for one year to review the possibilities of its effective action. The Committee had functioned

for some time on a standby basis to serve if and when occasion arose.

Correspondence has indicated that a majority feel that effective action is not possible and that the Committee should be discharged.

RALPH M. CALDWELL, Chairman

Report of the Committee on Fungicide Colloquium. The national controversy in pesticide residues has quite naturally involved plant pathologists. In spite of the scare headlines, the question still remains whether there actually is now or ever will be a significant misuse of pesticides. This situation has sparked strongly divergent opinions, and has been discussed at every Fungicide Colloquium held since 1955. The 1960 Colloquium could have been devoted entirely to the present controversy. This kind of a program, however, may not be of general interest to the members of the Society.

It was decided, therefore, to devote a third of the 1960 program to the pesticide residue problem. Director Noble Clark, who will speak on the subject at Green Lake, supports a cooperative spirit to find answers to this national question, rather than to spend more time in defending divergent points of view. The rest of the program at Green Lake will be devoted to current problems in the discovery and development of plant protectants.

Because of the widespread interest in fungicide development and use, the Society should have a forum for the discussion of these activities. The Fungicide Colloquium serves as a symposium for broad areas of chemical control of plant diseases. This does not duplicate the highly specific research reports presented in the Fungicide Section. For this reason, we suggest the continuation of the Fungicide Colloquium.

The Chairman wishes to express his appreciation for the excellent support and advice he has had from the committee membership.

SAUL RICH, Chairman

Report of the Committee on Industrial Relations. The Industrial Relations Committee had no organized program during 1960. There were no calls for assistance from the Society and no other business was transacted. No suggestions for other activities were received.

In view of the reduced work load of this Committee since the gathering of financial support from industry for the Golden Jubilee Celebration of the Society in 1958, it seems that the Committee might be reduced in size or placed on a standby basis.

PAUL F. HOFFMAN, Chairman

Report of the Advisory Committee on Nematology. The Advisory Committee on Nematology arranged for Dr. Robert S. Roe, Director, Bureau of Biological and Physical Sciences, Department of Health, Education and Welfare, Food and Drug Administration, to be the principal speaker at the nematology discussion meetings scheduled for August 28 at the Green Lake meeting. Dr. Roe's subject was "Pesticides, Nematocides, and Tolerances."

J. N. SASSER, Chairman

Report of the Committee on Teaching Plant Pathology. Supported by a National Science Foundation Grant, a project to prepare a sourcebook of laboratory exercises in plant pathology was initiated. A four-day planning conference was held at Pennsylvania State University in September, 1959. Members of the planning conference were as follows: C. W. Boothroyd, B. H. Davis, I. W. Deep, Stephen Diachun, J. P. Fulton, J. Walter Hendrix, A. Kelman, J. E. Mitchell, J. H. Owen, W. H. Sill, R. B. Stevens, and R. Zabel. In addition, the following persons were invited to participate in the initial phases of the planning session: G. C. Kent, G. S. Pound, G. L. McNew, M. Moore, and J. Oswald. At the planning conference, the basic objectives of the sourcebook and a detailed outline of subject matter to be included were prepared. Responsibility for specific phases of the program was assigned to individuals and a nation-wide solicitation of teaching exercises was scheduled. To foster interest in the sourcebook project, J. Fulton and J. Owen held a discussion meeting at the Annual Meeting of the Southern Section of the APS at Birmingham in February.

In addition to the laboratory sourcebook project, the Teaching Committee is considering proposals for a series of illustrated life cycles of major plant pathogens and an issue of the AMERICAN BIOLOGY TEACHER devoted to the subject of phytopathology.

ARTHUR KELMAN, Chairman

Report of the Committee on Membership. The Committee on Membership contacted the major centers of plant pathology in all the states. It is difficult at this time to determine the over-all results of the membership drive, but it is assumed that it had considerable effect on introducing new members into our Society.

WILLIAM B. HEWITT, Chairman

Report of the Committee on Utilization of Plant Pathologists and Facilities in National Emergencies. The Committee, within its mission on national emergencies, contacted the Office of Civil Defense Mobilization (OCDM) in regard to possible assistance from the American Phytopathological Society to the OCDM on matters pertaining to biological warfare, plant pathologists, plant diseases, and technical information. The information in the reply of May 4, 1960, from OCDM was referred to the APS.

The Committee received no requests from plant pathologists in the Armed Forces for assistance in obtaining a scientific assignment.

The Committee recommends (1) that the Committee be continued for 1961; (2) that, unless the Council prefers to place the responsibility in a special committee, the Committee's mission be extended to include matters relative to Civil Defense; and (3) that, if recommendation No. 2 is approved, the Committee's

title be changed to "Civil and Defense Mobilization, Planning and Services."

H. H. THORNBERRY, Chairman

Report of the Committee on Virus Type Culture Collection. The Committe report, "Serological studies of commercially produced plant-virus antisera," appears in the June issue of PHYTOPATHOLOGY. The eight antisera listed in Table 1, represent the efforts of the Committee, Society members who collaborated with the Committee, and Microbiological Associates. In Table 2 are listed the antisera in use in five laboratories in the United States and in two Canadian laboratories. Much hard work went into this project, and at this point the Chairman wishes to point out that all of the animal work done by Mr. Monroe Vincent, of Microbiological Associates, was without cost to the Society. It was this contribution and able assistance, the generous contributions of purified antigens by the collaborators, and the untiring efforts of Dr. Moorhead and Dr. Brakke that made the project possible, and in the Chairman's humble opinion, successful. A new antiserum project is underway with the Microbiological Associates.

During the past year, the American Type Culture Collection (ATCC), with the encouragement of the NIH, decided to expand and seek support for larger quarters. In view of this, the Chairman of this Committee felt that the time was right to consider a complete centralization of the plant-virus collection and an antiserum program in the ATCC. A canvass of the Executive Committee and the Director of the ATCC, of the virus Committee and several other interested Society members has indicatd a favorable reaction to such a plan, and the Executive Committee is now polling the ATCC Board members for a decision on the plan.

Centralization of the plant-virus collection will entail: (1) facilities for the culture of plants; (2) production of those viruses that can be transmitted by manual methods of inoculation, and possibly certain others; (3) preservation of these viruses on the premises of the ATCC; (4) purification of virus antigens for the production of antisera; (5) production of antisera by the ATCC or by a contractor to whom the ATCC will supply the purified antigens; (6) maintenance of an antiserum bank; (7) maintenance of a virus identification service; and (8) research directed towards the improvement and standardization of methods for the production and preservation of viruses, and the preparation of antigens and the antisera in cooperation with the APS.

To improve the status of the ATCC as an educational institution and to increase the interest in and the sale of certain plant pathogens (bacteria, fungi, and viruses), it is proposed that the ATCC and the APS develop a plant pathology project program and a project handbook for use in high schools. Such a program, based on living plant materials, would effectively augment the AIBS biology film project, and it might be worked out in cooperation with AIBS or with Science Service. A tentative list of projects and pathogens prepared by the Chairman was submitted to Mr. Willis H. Wheeler of the U. S. Quarantine Service for an opinion. This was favorable; he foresaw no insurmountable obstacles in most of the states, and he expressed hearty support of the proposal. The Committee, and others with whom the proposal has been discussed, favor it.

The centralization of the plant-virus collection, the expansion of other departments of the Collection, and a strengthened educational program will greatly increase the range and the number of potential sources of contributions, gifts, and grants to the ATCC. The high school project proposal was discussed informally with people in the U. S. Office of Education, and there seems to be a possibility that the ATCC may be able to qualify for certain types of grants from that source for such a project. From the standpoint of the Society, such an educational program should serve well in the "Development of liaison between scientists (plant pathologists) and the public on a local basis." This is Point 4 in the AAAS' recently proposed 4-point program relating to an informed public in the July 8 issue of SCIENCE, p. 72, col. 3.

The Secretary will be informed on the decision of the ATCC Board concerning centralization of the plant-virus collection.

H. H. MCKINNEY, Chairman

Report of the Advisory Committee on Collecting and Disseminating Data on New Fungicide Tests. Dr. A. B. Groves has continued the private publication of the "Report." This year the title was appropriately changed to "Results of 1959 Fungicide and Nematocide Tests" to emphasize the enlarged scope of coverage. Also, the cover was changed and the size of the report cut to 8 x 10½ in. to conform with the format of PHYTOPATHOLOGY and permit filing with copies of the same. A condensed Table of Contents was included on the cover to facilitate ready reference. In line with efforts to continue early publication, the "Report" was available in early March. Credit for all these changes goes to Dr. Groves.

The Council recommended that greater publicity for the "Report" might be had through additional ads in PHYTOPATHOLOGY. This was accomplished through insertion of such ads in the March and April issues. Also, a flyleaf for insertion in the Society mailings was proposed to announce both the availability of the Report and solicitation for future reports. This flyleaf was included in the Secretary's mailing of March, 1960. In addition, news releases were obtained through the continued helpfulness and cooperation of the PLANT DISEASE REPORTER and AGRICULTURAL CHEMICALS. Notices also appeared in CROPLIFE, SCIENCE, JOURNAL OF ECONOMIC ENTOMOLOGY, AIBS BULLETIN, BETTER FARMING METHODS, AMERICAN POTATO JOURNAL, AMERICAN FRUIT GROWER, CROPS AND SOILS, and NAC NEWS. Notices were also mailed to all prior

purchasers. It is considered that this publicity is increasing the demand for copies of the "Report" as indicated from the increase in sales this year.

It should be noted that while the increase in size and coverage of the "Report" since the 1956 edition has been substantial, there is a tendency for some stabilization at present. The number of reports is down from the previous year, and this could be reflected in the pagination remaining about the same as for 1958.

The status of the project as of June 30, 1960, may best be given from Dr. Groves' statement as follows:

"Sales of the report continue to increase. Nine hundred fifty-eight (958) copies of the 1959 report were sold through June 30, an increase of 244 copies over sales at the same date a year ago, and 283 copies over sales on June 30, 1958. Sales will certainly go over 1,000 for the first time with the 1959 report; if sales continue after July 1 at the rate of the past two years, the edition will be exhausted in a few months.

"A few copies of earlier editions continue to be sold. Complimentary copies were provided all 1959 cooperators as well as those who had cooperated earlier and requested a copy. It is felt that this action is important to maintain cooperator interest and participation in the project.

"Efforts are continuing to be made to enlist the cooperation of all investigators in fungicide and nematocide testing, wherever they may be located. The number of foreign reports has increased substantially and should increase further. Every state and Canadian province is included in the present list of cooperators.

"Improvements in quality of reports continue as an objective, and it is felt that progress is being made. Efforts are being made to reduce errors and misinformation relative to material sources and composition."

Consequently, with suggestions made by Dr. Groves and discussions with Committee members, the following recommendations are being submitted for consideration, advice, or action by the Council:

1) Approval of the continued publication of results of fungicide tests.

2) Publication of the "Report" to be continued on a private basis unless a more desirable arrangement can be offered within the scope of the Society's publication program.

3) Continue the price at $1.00 per copy unless some emergency situation should develop prior to publication.

4) Enlargement of the Committee to include associate editors to assist Dr. Groves in covering nematocides and fungicides on vegetables, ornamentals, etc. The Committee would like to meet during the Annual Meeting to consider possible candidates for recommending to the Council for approval.

5) Unqualified commendation should be given Dr. Groves by the Council for his continued outstanding efforts in increasing the quality and coverage of the "Report" as an important contribution of the Society and through his excellent administration of the project.

6) Approval of the reappointment of Dr. A. B. Groves as coordinator of the project for the coming year. He has so indicated his willingness to accept because of his desire to provide for further improvements and ideas in this project and his belief that the "Report" is of real service.

L. Gordon Utter, Chairman

Report of the Advisory Committee on Integration of Research on Soil-Borne Pathogens. A Committee meeting was held in Montreal at the time of the International Botanical Congress. Also, on several occasions during the year, the Chairman has had an opportunity to discuss with several members of the Committee the various matters before it.

The Committee has expressed itself in favor of listing papers at meetings under root diseases rather than under crop headings. It has also encouraged certain abstracting journals to index papers in a similar manner in addition to present listings. On many occasions during the year, members of the Committee have acted individually to encourage research in this area and the exchange of information through representation at the several meetings at which root diseases have been discussed.

Two members of the Committee are members also of the NRC Subcommittee on the Biological Control of Soil-Borne Pathogens. The interests of these two committees have been integrated, and considerable progress has been made in a joint effort toward arranging an international conference on the basic aspects of root disease research.

The Committee feels that there is a continuing need for activity in the area of its assignment.

William C. Snyder, Chairman

Report of the Special Committee for Services to Manufacturing and Editing PHYTOPATHOLOGY. Exploration of possibilities of providing a central service for PHYTOPATHOLOGY has been continued. Within the year there was proposed to the Committee by AIBS a redactory service for the publication of PHYTOPATHOLOGY. This service was offered at a figure of approximately $7,400 a year. The Committee was not in agreement as to the wisdom of accepting this offer, and it was decided that it would be better for the new editor-in-chief to be chosen before any recommendation was made to the Council, so that the new editor-in-chief could have some voice in the direction in which we should move. With this in mind, committee deliberations were stopped until the Council could name a new editor-in-chief. In choosing a new editor-in-chief, it was found that essentially the same service offered by AIBS, and for the past three years by the University of California, can be obtained on the campus of the University of Wisconsin for at least $2,500 per year less than asked by AIBS. We are sure the new editor-in-chief, Dr. R. W. Fulton, will make this proposal to the Council.

G. S. Pound, Chairman

Report of the Advisory Committee on Agricultural Meteorology. The Committee was appointed in 1958 and has continued to serve in a liaison capacity between the American Phytopathological and the American Meteorological Societies. In this capacity, a member of the Committee met with representatives of other biological societies and of the meteorological society at the Third National Conference on Agricultural Meteorology held in Kansas City. The meteorological society was urged to publish a monograph in agriculture and to sponsor future conferences, while the biologists accepted the suggestion of sponsoring symposia in meteorology within their societies.

A symposium on "Weather and Plant Disease" is being sponsored by the Committee at the 52nd meeting of the Society at Green Lake in 1960.

P. E. Waggoner, Chairman

Report of the Special Committee for Study of Possible Microbiological Center. The Committee met in Washington in March with the Director of the American Type Culture Collection to consider the expansion of the ATCC in the direction of a major microbiological center. The Committee feels that the most logical and promising development of such a center is through expansion of the existing organization of the ATCC. Considerable progress has been made by the present Director of the ATCC, Dr. W. A. Clark, and the Committee is working closely with him.

The Committee notes with satisfaction this progress toward the creation of a Microbiological Center, and believes that the Society should support vigorously the efforts of the ATCC to obtain the funds necessary to provide the space and facilities needed.

William C. Snyder, Chairman

Report of the Ad Hoc Committee to Study Committee Functions and Annual Meeting Programs. At the meeting at Pennsylvania State University, the Council set up a committee to study the present committee structure of APS, the program format of our annual meetings, etc., and to make recommendations to the Council for changes which would bring about more effective operation and programming of the Society and its committees. This committee began an immediate study and respectfully submits the following report for Council consideration.

I) COMMITTEES

A) *Change the basic concept of our Program Committee.* The Standing Rules of the Constitution call for a program committee of an executive nature in that it is made up of the President, Vice-President, Secretary, and Editor-in-Chief. This provision was perhaps adequate in the early days of the Society, but it is no longer so. Our annual programs should be built around subject matter fields of great interest to Society members, and this can be done best if the various subject matter interests have a hand in shaping the program. It is our recommendation, therefore, that the Standing Rules be revised (see attached proposed change) to establish a Program Committee (under Council control by having the President-Elect serve as Chairman) that will be broadly representative of the various subject matter areas of Plant Pathology. This can be done easily by establishing a number of subject matter committees, the chairmen of which will be members of the Program Committee.

The establishment of these subject matter committees could go a long way toward caring for interest groups within our Society. In addition to helping shape our annual program through their representation on the Program Committee, they could take care of any other activity related to their specific subject matter areas.

A program committee such as the one proposed would have the thinking of many of our members available to it. The chairman of each subject matter committee, in order to best represent his area, would counsel with other members on his committee for program ideas. These persons in turn would counsel with colleagues at their own institutions.

1) *Composition of the Program Committee.*

It is our recommendation that the Program Committee be constituted as follows: the President-Elect who will serve as Chairman, the Secretary, the Chairmen of the Committees on Industry, Extension, Public Relations, Teaching, and the Chairmen of seven subject matter committees to be established. These are as follows:

Chemical Control
Disease and Pathogen Physiology
Epidemiology and Meteorology
Host Resistance and Microbial Genetics
Plant Nematology
Plant Virology
Soil Microbiology

This will give a program committee of 13 persons, which admittedly is large but which, seemingly, cannot be any smaller. Considerable difficulty is encountered in placing such committees as Teaching, Public Relations, Industry, and Extension in or out of the subject matter group. After long consideration of this problem, we recommend not including them but giving them representation on the Program Committee. Additional subject matter committees could be established when needed.

2) *Functioning of the Program Committee.*

In order to provide desired continuity of program, the Council may wish to appoint subject matter committee chairmen for terms of more than one year. This would give needed continuity of thinking and should result in very effective programming. The Committee should meet at the annual meetings and lay plans not only for the next year's annual meeting but tentative plans three or four years in advance, and also should plan programs and conferences in conjunction with other organizations. This should result in a marked upgrading of the quality of our programs.

B) *Recommended committees for APS.* It is our opinion that we need only Standing and Special Committees and that all of our committees be considered one or the other. It will not be necessary to change the Constitution in that the Council can simply refrain from appointing temporary committees. With this in mind, we recommend the following committees. Some detailed recommendations accompany the listing.

STANDING COMMITTEES

I) Program Committee (see Section A above)

II) General

A) Archives (This will replace our current "History" Committee. Since our Committee is not a history committee but rather one to collect and maintain records which are or may become of historical significance, we feel that this change is appropriate.)

B) Extension

C) Finances and Investments

D) Industry (This will be a committee of industry people which will replace our Industrial Relations Committee and which will represent industry interests in our profession. If Industry desires to continue the Fungicide Colloquium, it is suggested that the programs be worked out in consultation with the Chemical Control Committee.)

E) International Cooperation

F) Membership

G) Placement

H) Publications

Subcommittees:

1) Phytopathological Classics

2) Phytopathological Monographs and Reviews

3) Phytopathological News Page

4) New Fungicide and Nematocide Data

This committee will be composed of the Editor-in-Chief of PHYTOPATHOLOGY, the chairmen of each of the subcommittees, and any additional member(s) the Council may choose. It need not change drastically the operation of the program now under way by various committees that we have on publications. It will bring all of our publications into a more closely knit package and provide the maximum amount of integrated consideration of our publications problems and programs. It will also mean that this committee can present a single report to the Council and can relieve the Council (and it needs relief!) of many administrative problems.

I) Public Relations (We feel that the Society should have a public relations program of greater scope and depth than heretofore. We need a strong program designed at public acceptance and public support of Plant Pathology. We suggest, therefore, that the leadership for this program should be persons who not only have good professional anchorage, but who have real promotional abilities, and that this committee be encouraged to initiate a truly significant program of public relations.

J) Regulatory Work and Foreign Plant Disease

K) Teaching

III) Subject Matter

A) Chemical Control (This committee should be composed of persons active in research in chemical control from either institutions or industry. The Fungicide Colloquium Committee should be dropped. The question of who will handle the fungicide colloquium, if it is continued as such, may become a problem. We think this committee should handle all program sessions where exchange of research information dealing with chemical control is the purpose of the meeting. There would seem to be no problem since both this committee and the Industry Committee will have representation on the Program Committee—see B,II-D.)

B) Disease and Pathogen Physiology

C) Epidemiology and Meteorology

D) Host Resistance and Microbial Genetics

E) Plant Nematology

F) Plant Virology

G) Soil Microbiology

IV) Special (Temporary) Comittees

A) Plant Disease Losses

B) Others as designated by the Council

II) ANNUAL PROGRAM

A) *Change format of Annual Program.* We believe that it would work to the betterment of all to place more emphasis on invitational research papers, more symposia, more individual addresses on professional and policy matters, and more conferences of workers in limited research areas. To this end we recommend a change in the Standing Rules (see attached proposed change) to permit the reduction of the number of contributed papers, at the discretion of the Program Committee.

We also suggest that the program committees consider scheduling contributed papers in sessions organized about basic subject matter rather than on a crops basis. We recognize that much research is organized and administered on a crops basis, but we believe it would be to the advancement of our profession to change this format.

To provide the type of annual program envisioned will require greater outlay of money than has been our practice. We recommend that the Program Committee be provided a budget on an annual basis which could be used to pay speakers' travel (where necessary) and any other type of expense the Committee deemed necessary. We suggest an initial appropriation of $2,000.

We also recommend that the second business meeting, which has for years been a part of our annual program, be dispensed with except when absolutely necessary. Our usual experience is that only purely perfunctory items of business are transacted here and the amount of business done has not justified the time that it has taken.

B) *Programs other than the Annual Meeting.* We recommend that the Program Committee, with Council approval, be empowered to sponsor, in the name of the Society, as needs may warrant, research conferences on specific topics in addition to the annual program. This would include joint participation in conferences or symposia with other professional biological groups such as AAAS, AIBS, Entomological Society, etc. It would seem that, on a regional or national basis, conferences of research workers in limited subject matter areas (e.g., Disease Resistance in Tomato, Control of Cereal Rusts with Systemic Fungicides, etc.) could be of great value to our membership. By this sort of thing a much broader over-all program could be had.

III) OTHER ITEMS

A) *A new communication organ.* We believe that we do not have adequate lines of communication among our members. Our news sheet each month carries many items of information but these are, of necessity, brief and provide no discussion. Many things happen and many problems arise which are not generally or quickly known by our members. We believe an additional means of communication is needed and that such a venture would be well received by our membership. One way that this could be accomplished is by establishing a news letter type of thing which could carry items of news and discussions of problems. Another possibility would be to start a second publication which would be slanted more to the applied side (such as "Plant Pathology," "Crops and Soils," etc.) but which could also carry our expanded news letter, the publication of new fungicide data, etc. The possibility of a second publication was studied about five years ago, but we do not recall that it considered such things as news, letters to the editor, new fungicide data, etc. This should have real study for it is a complex thing. We recommend that the Council give study to this possibility.

GLENN S. POUND, Chairman

(The proposed changes in Standing Rules 3 and 6(b) referred to in the above report are presented in the Report of the General Business Meeting.)

Report of the Committee on Plant Disease Losses. This Committee was established by the APS Council at the Penn State Meeting, August, 1959, at the request of the Agricultural Pest Committee of the Agricultural Board (National Research Council).

The first meeting of the Committee was November 4-5, 1959, at the National Academy of Science Building, Washington, D. C., in conjunction with a conference on Agricultural Pest Losses, sponsored by the Agricultural Board. Two days were spent in reviewing the need for more accurate information on losses to crop plants by diseases, insects, nematodes, weeds, and wildlife. Considerable discussion was held also upon the need for research to improve the gathering of accurate data on losses from these pests.

Each loss group—diseases, insects, weeds, etc.—met separately for two half-days to discuss its specific areas. From the plant disease group a resolution was formulated and later adopted by the conference-at-large as follows:

> A RESOLUTION TO DEVELOP FURTHER WORK ON AERIAL SURVEY RESEARCH
>
> The Committee on Agricultural Pests recommends that the Agricultural Board take appropriate action to encourage research on the use of aerial photographic surveys during the growing season of agricultural crops to determine incidence and severity of damage caused by diseases, insects, weeds, nemas, and wildlife. An earlier project sponsored jointly by the National Academy of Sciences—National Research Council and the Office of Naval Research has demonstrated the utility of this method in detecting incidence and severity of cereal rusts (Colwell, R. N., 1956. Determining the prevalence of certain cereal crop diseases by means of aerial photography. Hilgardia 26:223-286). We believe the method offers great value for obtaining qualitative and quantitative data on the incidence and severity of damage to crops by nearly all pests, but three to five years of intensive research effort will be required before the method can be widely applied and the degree of usefulness determined.
>
> The Committee on Agricultural Pests believes that photographic data can be widely useful for purposes other than determining the incidence and severity of damage by pests.

The Chairman of the Plant Disease Committee was charged with following up the proposal during the winter. The three letters appended summarize these efforts. At a meeting of the Executive Committee of the Agricultural Board June 25, 1960, at Cleveland, Ohio, Dr. Dutton's recommendation of June 21 was approved, and the Aerial Survey Committee will be set up during the summer of 1960 as a subcommittee of the Agricultural Pests Committee. This group will organize support for studies to determine the application of aerial detection of pest losses to agricultural crops. It is believed from Dr. Robert Colwell's pioneer work that plant disease detection by aerial means is of special merit for such studies.

In addition to this project, the Plant Disease Loss Committee has arranged a Symposium at the Green Lake, Wisconsin, meetings in August, 1960, to re-emphasize the importance of disease loss information and to bring to the membership of the Society a summary of the existing information on aerial detection of plant diseases in crop plants.

J. R. SHAY, Chairman

Report of the Resolutions Committee. WHEREAS, we have, through the hospitality of the University

of Wisconsin and the American Baptist Assembly, enjoyed sunny and serene surroundings for this 52nd annual meeting, BE IT RESOLVED:

THAT the members of the American Phytopathological Society express special thanks to:

a) The American Baptist Assembly for providing the splendid accommodations and facilities for the annual meeting and for the sober consideration of Society affairs.

b) The American Baptist Assembly for an enlightening experience in true, Midwestern living, silos and all.

c) The staff of the University of Wisconsin and its able leader, Dr. G. S. Pound, for serving admirably as hosts to the Society.

d) The members of the Local Arrangements Committee for giving generously the many hours of preparation that have made this 52nd annual meeting a success.

THAT the Society appoint Dr. J. E. Kuntz and his assistant as permanent coordinators of children's affairs for all future Society functions, and that the Council consider sending Dr. and Mrs. Kuntz to Disneyland for a much deserved rest and for further inspiration.

THAT in the interest of propriety, in the future no more than four 3′ x 4′ portraits, two 6′ x 8′ portraits, or one mural shall be presented during any one annual meeting.

THAT the members here assembled give a round of applause to the members of the Assembly staff, who have served us so efficiently and cheerfully here in the dining hall.

J. R. PARMETER
E. L. KENDRICK
S. RICH

Interim and Ad Hoc Appointments and Other Action. President W. C. Snyder appointed the following representatives and delegates of the Society during the year: K. W. Kreitlow and W. H. Sill, Jr., as official representatives to the 8th International Grassland Congress in England; F. F. Smith as official delegate to the 11th International Congress of Entomology in Vienna; D. E. Ellis as representative at the installation of the New Chancellor at North Carolina State College; H. E. Reed as representative at the installation of the new President of the University of Tennessee; G. M. Watkins as representative at the inauguration of the new President of the A & M College of Texas; and H. C. Young, Jr., as representative at a meeting of the Special Committee of the Botanical Society of America at Stillwater, Oklahoma.

By mail ballot the Society approved in March 1960, by a vote of 429 to 5, the following change in Standing Rule 2(e) of the Constitution. The Standing Rule which read:

"*Subscriptions and Back Numbers.* Subscriptions to PHYTOPATHOLOGY shall be $10.00 per year, domestic and foreign. The price of single current numbers, within 60 days of publication, shall be $1.00. The sale price of back volumes or numbers shall be determined by the Business Manager with the approval of the Council. Requests to supply lost copies of the journal without charge must be made within 60 days from date of issue (January 15 and monthly thereafter)."

was changed to read:

"*Subscriptions and Back Numbers.* The price of non-member subscriptions to PHYTOPATHOLOGY, the price of single current numbers, and the sale and price of back volumes of numbers shall be determined by the Business Manager with the approval of the Council. Requests to supply lost copies of the Journal, without charge, must be made within 90 days from date of issue."

Report on Elections and General Business Meeting of APS and the Council. On Sunday, August 28, the Council, with President W. C. Snyder presiding, considered reports of officers, representatives, and committees; prepared recommendations for consideration at the annual business meeting; and considered old and new business. The ballots of the annual election were counted by a special committee appointed by President W. C. Snyder and approved by the Council. The following officers were elected by majority vote: President-Elect, WILLIAM B. HEWITT; Vice-President, C. S. HOLTON; Councilor-at-Large, A. L. TAYLOR. The Council appointed ARTHUR KELMAN to fill C. S. Holton's one year unexpired term as Councilor-at-Large.

By majority vote at the general business meeting on Monday, August 29, the Society approved the recommendations of the Council appointing representatives, editors of PHYTOPATHOLOGY, and committee members, as listed above.

By unanimous vote the Society approved the following recommendations of the Council:

1) That Standing Rule 3 of the Constitution which reads:

"The program for the annual meeting shall be in charge of a temporary committee consisting of the President, Vice-President, Secretary, Editor-in-Chief, and such additional members as the President may select. This committee shall have full authority over the scheduling of sessions and demonstrations, and the allocation of papers."

be changed to read as follows:

"The Program Committee for the annual meeting and for other such meetings in which the Society may participate shall be in charge of a Standing Committee consisting of the President-Elect who shall serve as Chairman, the Secretary, the Chairmen of the Committees on Extension, Industry, Public Relations, Teaching, and the Chairman of each of the Standing Committees which the Council shall determine as Subject Matter Committees. The Program Committee shall have full authority over the scheduling of sessions, demonstrations, and informal conferences, and the selection of subjects and speakers for invitational papers."

2) That standing Rule 6 (b) of the Constitution which reads:

THAT in the future, the staff and alumni of the host institution shall not banquet on chicken while the remainder of the Society is served ham.

"At least one author of each paper must be a member of the Society. An author cannot appear on more than two papers."

be changed to read as follows:

"At least one author of each paper must be a member of the Society. An author cannot appear on more than two papers; at the discretion of the Program Committee this number may be reduced."

3) That the Committee structure be changed in accordance with the outline of committees given earlier in this report, as recommended by the Ad Hoc Committee under the chairmanship of Glenn S. Pound. This reorganization involves the dismissal of seven committees, with incorporation of their duties elsewhere in the new organization.

4) That the application of a group of plant pathologists in the Caribbean area, presented by F. L. Wellman, to form a new Division of the Society to be known as the Caribbean Division, be approved.

5) That Standing Rule 1 (a) of the Constitution which reads:

"The dues, including subscription to PHYTOPATHOLOGY, for all Annual Members as defined in Article II, Section 2 (b) of the Constitution shall be $10.00 a year, and for Student Members, as defined in Section 2 (c), shall be $5.00 a year. In order to qualify for the rate as a Student Member, applicants must submit with their dues each year a certificate of student status endorsed by their major professor or the head of the department of instruction."

be changed to read:

"The dues, including subscription to PHYTOPATHOLOGY, for all Annual Members as defined in Article II, Section 2 (b) of the Constitution shall be $12.00 a year, and for Student Members, as defined in Section 2 (c), shall be $6.00 a year. In order to qualify for the rate as a Student Member, applicants must submit with their dues each year a certificate of student status endorsed by their major professor or the head of the department of instruction."

6) That AIBS be paid on the basis of $1.00 per total membership so that all members (domestic and foreign) will receive the AIBS Bulletin.

7) That the Society approve the following Resolution submitted by J. A. Stevenson, Representative to American Type Culture Collection:

WHEREAS the American Type Culture Collection in the course of developing the several functions set forth in its constitution, namely, "to collect, preserve, and disseminate authentic cultures of fungi, bacteria, and other micro-organisms and to carry on the research necessary to solve problems arising from such activities," has outgrown its quarters;

WHEREAS the Collection has been requested by various agencies to undertake new and diverse activities all related to its work involving much enlarged collections and a broadening of its research activities;

WHEREAS space is not now available to house the additional personnel necessary to properly carry on the anticipated added projects of the Collection or the added equipment which will be involved:

BE IT RESOLVED that the American Phytopathological Society actively support the American Type Culture Collection in its efforts to obtain funds from all possible sources to build an adequate laboratory and service.

8) That a budget of $1,500 again be made available to the Committee on Public Relations for the coming year.

9) That a budget not to exceed $2,000 be made available to the Program Committee for the coming year.

Future Meetings. The Society will meet in Biloxi, Mississippi, December 10-13, 1961; and at Oregon State College, Corvallis, Oregon, with the AIBS in late August, 1962. W. W. Hare was appointed Chairman of Local Arrangements for the 1961 meeting.

Interim Action by the Council. The Council, with President W. C. Snyder presiding, met on Monday, August 29, and took the following action:

1) Approved the project proposed by the Teaching Committee to produce a special Plant Pathology issue of the American Biology Teacher, and approved the appointment of a Special Committee to deal with this project.

2) Approved the investigation of procedures of appointing committee members and the examination of committee tenure and duplication of membership by a special Council committee, with W. W. Hare as Chairman.

The new Council, with President S.E.A. McCallan presiding, met on Wednesday, August 31, and took the following action:

1) Authorized President McCallan to appoint the Special Committee on the American Biology Teacher issue dealing with Plant Pathology.

2) Approved a project to develop colored illustrations of plant disease life cycles and other illustrations dealing with plant diseases by an artist, approved the sum of $2,000 for this purpose, and authorized the appointment of a special committee by President McCallan to investigate the project, including additional means of financing.

3) Approved the proposal by the group in Plant Pathology at Purdue University to sponsor a teaching conference on plant pathology prior to the AIBS meeting at Purdue in August, 1961.

4) Approved the formation of two additional Subject Matter committees on Mycology and on Bacteriology. W. C. Snyder was appointed Chairman of the Committee on Mycology, and R. S. Dickey was appointed Chairman of the Committee on Bacteriology, with additional committee appointments to be made by President McCallan on consultation with these chairmen.

5) Approved the following recommendations of the Special Committee on Publications and Public Relations:

a) Expansion of the News page in PHYTOPATHOLOGY.

b) Incorporation of editorials by the President or designated guest writers near the News page section of PHYTOPATHOLOGY.

c) Initiation of a Letters-to-the-Editor section of PHYTOPATHOLOGY.

6) Moved to authorize and encourage attendance of the President or an officer designated by him at Divisional meetings, and approved expenses for travel involved.

GEORGE A. ZENTMYER, Secretary

REPORT AND ABSTRACTS OF THE 1960 ANNUAL MEETING OF THE PACIFIC DIVISION OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The 42nd Annual Meeting of the Pacific Division of the American Phytopathological Society was held with the Pacific Division of the AAAS on the campus of the University of Oregon, at Eugene, June 15 and 16, 1960. In addition to contributed papers, an invitational symposium was held on "Disease-Free Planting Stock."

On June 17, members of the Society went to Corvallis as guests of the Department of Botany and Plant Pathology of Oregon State College. There the Department held open house and conducted a field-plot tour for guests, followed by a chicken barbecue at Avery Park.

Officers elected for 1960–61 were: President, P. D. Menzies; Vice-President, W. A. Kreutzer; and Secretary-Treasurer, C. J. Gould.

Changes in soil mycoflora following treatment with fungicides.—*Malcolm E. Corden and Roy A. Young.*—Changes in soil mycoflora following treatment with fungicides and in the sequence of reinfestation can be important factors in re-establishment of plant pathogens. Changes were investigated in soil treated with methylmercury oxinate (MO), Mylone, Vapam, nabam, and 2-chloro-3-(tolylsulfonyl)-propionitrile (CP 30249) applied to freshly collected field soil at the ED_{95} concentration for *Fusarium oxysporum* f. *cubense* in soil. Samples of treated soil were reinfested periodically with spores of the fungus and/or with untreated soil. Changes in the fungal population during a 3-month period following treatment were determined by dilution plate techniques. In all treated soils fungi initially decreased. Eventually *Trichoderma* spp. increased moderately in soil treated with nabam and CP 30249. *Penicillium* spp. increased slightly following Vapam treatment, but increased to a level 3 times the original total fungal population in soil treated with MO. Following Mylone treatment the soil fungal population decreased continually, but was re-established readily when soil was reinfested 1 day after treatment. *F. oxysporum* f. *cubense* was established in soils 1 week following treatment except in MO-treated soils, where 1 month delay was required. The infestation was always greater in treated than in untreated soils.

The effect of environment on the toxic action of sulfur dioxide on the spores of *Botrytis cinerea*.—*H. Melvin Couey and M. Uota.*—The effect of sulfur dioxide gas on the spores of *Botrytis cinerea* was studied to provide a basis for improving sulfur dioxide fumigation of table grapes. When *Botrytis* spores are exposed to sulfur dioxide gas, the reduction in spore germination is quantitatively proportional to the sulfur dioxide concentration and the exposure time. The toxicity of sulfur dioxide increases with increasing relative humidity. Sulfur dioxide is more than 20 times as effective at 96% RH as at 75% RH. The toxicity also increases about 1.5 times for each 10° rise in temperature between 0° and 30°C.

Seed and pollen transmission of Prunus ringspot virus in Buttercup squash.—*C. R. Das, J. A. Milbrath, and K. G. Swenson.*—Seed transmission of Prunus ringspot virus in Buttercup squash was proved when 1316 seeds from infected plants produced 34 infected plants. Pollination had not been controlled, but the seed came from diseased plants in plots where both diseased and normal pollen was present. An experiment was designed to compare the effects of diseased or healthy ovaries and pollen on subsequent seed transmission. The following data were obtained: healthy ovaries–diseased pollen, 0/3152 diseased plants; diseased ovaries–healthy pollen, 17/2213 diseased plants; diseased ovaries–diseased pollen, 7/1546 diseased plants. Virus in the ovary rather than virus in the pollen appears to be the controlling factor in seed transmission. Eight of 49 healthy plants became infected during pollination with diseased pollen. In a greenhouse experiment 3 of 81 plants became infected when pollinated with diseased pollen, whereas 81 adjacent unpollinated plants remained healthy. Although mechanical inoculation by rubbing during pollination was not eliminated in either experiment, virus transfer by pollen is suggested.

Controlling Penicillium decay of oranges with certain aliphatic amines.—*J. W. Eckert, M. J. Kolbezen, Brigitte F. Bretschneider, and H. K. Nicholas.*—Thirty-five aliphatic amines were evaluated for decay control in oranges artificially inoculated with *Penicillium digitatum*. Applied at the rate of 1 g per 0.25-ft^3 fiberboard carton, 12 amines reduced decay over 50% of the control value. Secondary butylamine, isopropylamine, diisopropylamine, diethylamine, and *t*-butylamine, in order of performance, were most satisfactory in decay control with minimum fruit injury. Paper inserts containing the carbonate, chloride, sulfate, phosphate, or acetate salts of isopropylamine, the latter 4 combined with excess Na_2CO_3, controlled decay at the rate of 2 g isopropylamine equivalent per 1-ft^3 fiberboard carton. Activity of amines as volatile fungicides is related to vapor pressure, inherent toxicity, and pH at the fruit inoculation site. Although the most effective amines have boiling points below 100°C., decay control is not directly correlated with amine boiling point. Amines with high vapor pressure bring about a rapid increase in pH of fresh fruit wounds that would otherwise be favorable to fungus infection. Certain amines, such as secondary butylamine, are more effective than would be predicted from their boiling points.

Use of pimaricin, penicillin, and polymyxin in isolating Phytophthora spp. from root tissues.—*J. W. Eckert, P. H. Tsao, L. J. Klotz, and Karla B. Jones.*—Isolating *Phytophthora* spp. from diseased roots by tissue plating is often difficult because of the presence of fast-growing or antagonistic secondary fungi and bacteria. Selective antibiotics were used to overcome this difficulty. The polyene antibiotics pimaricin and nystatin, active against a large number of non-oomycetous fungi, did not inhibit the growth or sporulation of *Phytophthora boehmeriae, P. cactorum, P. capsici, P. cinnamomi, P. citrophthora, P. cryptogea, P. erythroseptica, P. hibernalis, P.*

parasitica, P. syringae, or *Pythium aphanidermatum, P. debaryanum, P. irregulare,* and *P. ultimum* when evaluated in agar at 100 ppm. In contrast, *Aphanomyces cochlioides* was strongly inhibited by both antibiotics. Of 13 antibacterial antibiotics tested, penicillin and polymyxin in combination, although noninhibitory to *Phytophthora,* were effective against the majority of soil bacteria. Corn-meal agar containing 100 ppm pimaricin (Na salt), 50 ppm penicillin (1650 units/mg) and 50 ppm polymyxin (7350 units/mg) was effective as a selective medium for isolating *Phytophthora citrophthora* and *P. parasitica* from infected citrus roots. The antibiotic medium generally allowed higher recoveries of *Phytophthora* and less interference from fungal contaminants than the same medium without the antibiotics.

A kinetic investigation of the mode of TMV attachment to infectible sites.—*Warren Furumoto and Sam G. Wildman.*—When *Nicotiana glutinosa* leaves are first injured by rubbing and then immediately immersed in a suspension of tobacco mosaic virus, the number of lesions produced is about ½ of that attained by rubbing the leaf directly with a TMV suspension. Extending the time between injury and immersion further reduces the susceptibility of the leaf to infection. Since a fraction of the susceptible cells remain infectible for a considerable period after injury, it was possible to perform certain kinetic experiments. It was found that the rate of loss of susceptibility is independent of the concentration of the TMV suspension and is thus strictly a property of the potentially infectible sites. Actual infection of the susceptible cells is dependent on the concentration of TMV and the length of time during which the rubbed leaves are immersed in the TMV solution. The data suggest that TMV attaches to these susceptible cells by an adsorptive process.

Effect of certain soil treatments on the development of bacterial canker in peach trees.—*Harley English, J. E. DeVay, Omund Lilleland, and James R. Davis.*—The effect of certain soil treatments on the development of bacterial canker (caused by *Pseudomonas syringae*) was studied in peach trees growing in a sandy soil of the San Joaquin Valley of California. The trees were planted on a site from which trees of the same variety (Red Haven) had been removed because of the disease. During the first 3 years after planting no trees were killed by canker where the soil was fumigated with either D-D (1,3-dichloropropene and 1,2-dichloropropane), or Picfume (chloropicrin) prior to planting. The percentages of trees killed by canker in the other soil-treatment plots were: NPK, 12.5; high nitrogen, 26.6; dolomite, 34.4; magnesium oxide, 39.1; manure plus moderate nitrogen, 39.1; calcium oxide, 56.3; fall irrigation, 67.2; low nitrogen, 85.9. The same amount of nitrogen was applied to all except the manure and low-nitrogen plots. Three-year-old trees in the chloropicrin plot were highly resistant to the disease resulting from artificial inoculation, whereas trees in the fall-irrigation plot were highly susceptible. Vigor of trees, as measured by trunk diameter, was significantly greater in the fumigated plots than in the other plots.

Pathogenicity and systemic development of Sphacelotheca reiliana in sorghum species.—*P. M. Halisky and L. J. Petersen.*—Head smut (*Sphacelotheca reiliana*) occurs commonly in Sudan grass, sorgo, and hybrid grain sorghums in California. The susceptibility of 3 Sudan grasses, 2 sorgos, and 7 hybrid and 8 common grain sorghums to smut inoculum from Sudan grass was demonstrated experimentally in the field. Infection was obtained from both seed-borne and soil-borne spore inocula. Seed inoculation of Ryer 15 grain sorghum produced trace infections (1–2%) whereas soil-borne inoculum produced considerably higher infections (15–60%). In Greenleaf Sudan grass, seed transmission of head smut prevailed in spite of seed treatment with formalin, Ceresan M, or Panogen 15. The systemic nature of smut mycelium was evident from leaf and culm sporulation, and from histological preparations showing fungus hyphae in the vascular bundles. The persistence of systemic mycellium in the crowns of 4 susceptible varieties was indicated by smut development in 2 successive crop stands separated by an 80-day growth interval. No latent infection developed in second-growth tillers of resistant or immune varieties. Two smutted plants of NK 210 hybrid sorghum bearing buff-colored sori with hyaline spores were also found. The colorless spores germinated by promycelia and lateral sporidia. This is believed to be the first report of albinism in *Sphacelotheca reiliana.*

Histological differentiation of fungal, chemical, mechanical, and insect damage to holly leaves.—*E. Anne Herridge.*—A comparison of the morphology and anatomy of normal and damaged leaves of *Ilex aquifolium* distinguished the four types of leaf spotting. Fungal and chemical damage are both effected through the stomata on the adaxial surface of leaves. Intercellular mycelium associated with irregular, translucent, or red-black swollen spots that ultimately appear on both leaf surfaces are the characteristics of fungal spotting. Hypertrophy and proliferation always occur in the spongy mesophyll and are frequent in the palisade. Chemical damage produces discrete, round spots, slightly raised, and always red-black spotting on the adaxial surface only. Enlarged mesophyll cells with unilaterally thickened, laminated walls fill the sub-stomatal chambers. These cells are the first to become necrotic. Extensive hypertrophy and proliferation occur in the chlorenchyma. Both mechanical and insect damage are stimulated by direct penetration of the cuticle and epidermis. Mechanical damage is distinguished by funnel-shaped lesions that penetrate the mesophyll to varying degrees. Phellogen is characteristic, and cork is a marked morphological feature. Lesions from insect injury generally involve individual epidermal cells, which are characteristically devoid of cell contents. If insects introduce the feeding organ intercellularly, hypertrophy and proliferation occur in the mesophyll.

Helicotylenchus nannus, a spiral nematode associated with declining gardenias.—*Donald E. Konicek and Harold J. Jensen.*—Gardenia plants, greenhouse-grown for commercial flower production, developed decline symptoms including: stunting of plants to one-half size of other plants planted at the same time; yellowing and premature dropping of leaves; failure to form flower buds and premature dropping of buds; and eventual death of the plant. Declining plants had fewer feeder roots and more sloughing of the cortex than healthy plants. Examination of the roots indicated that the cause may be *Helicotylenchus nannus.* Nematode colonies could be observed feeding on roots washed free of soil. Colonies of 5–15 nematodes were found on both the main root system and the feeder roots. Points of initial infection developed small brown circular areas that probably coalesced and attributed to the sloughing of root cortex in more severely infected areas. A gallon of soil taken from around declining plants yielded more than 20,400 spiral nematodes. Pathogenicity studies are now in progress.

The effect of near-ultraviolet irradiation on the sporulation of certain fungi.—*Charles M. Leach.*—Fluorescent lights have been used to make fungi sporulate. Filtering this radiation demonstrated that near-ultraviolet rather than visible radiation stimulated sporulation of those fungi studied. Fluorescent blacklamps were used to generate near-UV (3200–3800 Å) at intensities from 76 to 470 μ watt per cm^2 total UV. Fungi that sporulated profusely when irradiated for 10 days continuously at 70°F through Pyrex glass were: *Alternaria tenuis, A. zinniae, Ascochyta pisi, Botrytis cinerea, Coryneum* sp., *Epicoccum nigrum, Fusarium oxysporum, F. roseum, F. solani, Helminthosporium avenae, Mycosphaerella pinodes, Ophiobolus graminis, Phoma trifolii, P. herbarum var. medicaginis, Phoma* spp., *Phyllosticta* sp., *Pyrenochaeta terrestris, Stemphylium botryosum, S. trifolii.* When 8 species were grown under both continuous UV and in darkness on buffered and unbuffered malt-extract, potato-dextrose, Czapek's, and water agars, the medium had little effect on sporulation except

for water agar, on which growth and sporulation were sparse. Nonsporulating strains of *Helminthosporium oryzae* under continuous irradiation produced conidiophores but no conidia unless irradiation was followed by a continuous dark period of not less than 4 hours. A 12-hour UV-dark alternating cycle gave maximum sporulation.

The relation of sporulation of Ascochyta pisi to wave length, intensity, and exposure length to monochromatic ultraviolet radiation.—*Charles M. Leach.*—*Ascochyta pisi* was cultured on malt extract agar and irradiated from 1/5 to 3840 seconds with wave lengths of 2378, 2536, 2652, 2804, 3022, 3341, and 3663 Å, each at 43 μ watt per cm^2. Pycnidium formation was induced by relatively short exposures at all wave lengths, whereas long exposures reduced or completely inhibited sporulation except at 3663 Å. The shorter the wave length, the less the exposure necessary to induce maximum sporulation, and the shorter the exposure required to inhibit sporulation. Irradiation of colonies at 2536 and 3663 Å at intensities of 43 to 344 μ watt per cm^2, indicated that the higher the intensity the shorter the exposure necessary to induce maximum sporulation, and the shorter the exposure needed to inhibit sporulation at the same wave lengths. Whether pycnidia developed on the surface or submerged in the substrate depended on wave length, intensity, and length of exposure. The size of pycnidia decreased significantly with increase of intensity and length of exposure. Irradiation affected the shape of conidia.

Antagonisms to nematode-trapping fungi in soil.—*R. Mankau.*—Attempts to introduce nematode-trapping fungi into agricultural soils have often been unsuccessful. This is evidently due in part to the presence of antagonistic organisms in the normal mycoflora of many soils. *Arthrobotrys arthrobotryoides* and *Dactylaria thaumasia* were gradually reduced and finally eliminated from a wheat-germ-enriched pasteurized soil but not from an unamended soil. In Petri-dish cultures many species of predacious fungi are inhibited by several *Penicillium* spp., *Aspergillus terreus*, and two different isolates of *Bacillus* sp. The germination of *A. arthrobotryoides* conidia was stimulated when exposed to a soil air-dried for 6 months immediately after adding moisture. After a further incubation period of 10 days, however, a mild antagonistic effect was observed on the germination of conidia. The germination of conidia exposed to natural field soil was reduced from 92.3% for controls to 34.6% on one soil and from 91% for controls to 57% for another soil. The germination of *Dactylella ellipsospora* and *A. dactyloides* conidia exposed to a natural field soil was respectively reduced from 97% for controls to 20%, and from 71% for controls to 35%.

The control of seed-borne safflower rust by steam.—*Arthur H. McCain and Joseph M. Ogawa.*—Teliospores of *Puccinia carthami* are killed by a 1-sec exposure to steam. Safflower seed may be exposed to steam up to 4 sec without adversely affecting germination. Safflower seed heavily infested with teliospores of *P. carthami* were dropped 4 times through a 1-ft coil of perforated copper tubing under steam pressure. This seed received a total exposure to steam of 1 sec. The seed was planted in moist steamed soil in flats held at 5°C for 1 week and then at 21-25°C for 3 weeks in a greenhouse. No rust-infected plants appeared in any of the 8 replications of 400 plants each. Untreated seed produced 17.4% rust-infected plants.

Evidence that beta-propiolactone can inactivate latent A strawberry virus in Fragaria vesca plants.—*P. W. Miller and T. R. Aspitarte.*—In preliminary greenhouse tests, applications of beta-propiolactone at rates of 4000–8000 ppm to all above ground parts appeared to inactivate the latent A strawberry virus in Fragaria vesca plants. Of 75 plants originally infected with latent A virus, 5 (6.6%) of those treated tested "virus-free" 15 months after treatment. Application of beta-propiolactone apparently eliminates the virus, as subclonal units from the treated plants were readily reinfected with latent A virus by excised leaf-grafts.

The hull rot disease of almond and the pathway for translocation of a toxin involved in symptom development.—*C. J. Mirocha, E. E. Wilson, and J. E. DeVay.*—*Rhizopus stolonifer, R. circinans, R. arrhizus*, and the brown rot fungi cause a hull rot and twig blight of almond. *Rhizopus* spp. were more frequently associated with the disease. The disease is characterized by the rotting of hulls and subsequent blighting of leaves and the shoot to which the fruit is attached. Both the vascular discoloration of the twig and the blighting of leaves occur on that side of the stem having the same vascular conection as the peduncle of the rotted fruit. The pathogen colonizes on the inner surface of the mesocarp but is not present in the tissue of the blighted twig, as proved by isolations and study of microsections. Consequently, it was postulated that a translocated toxin is involved in the development of leaf and twig symptoms. It was necessary to demonstrate a pathway for translocation of a toxin from the fruit to the twig and leaves at the time of disease development. This was done by applying P^{32} to the mesocarp of the fruit when the hulls begin to open (dehisce) along the suture. In both healthy and infected fruit, P^{32} moved from the fruit and distributed itself in the leaves in a pattern resembling that of disease symptoms.

Influence of soil moisture and temperature on survival of Verticillium microsclerotia.—*M. J. Nadakavukaren and C. E. Horner.*—The influence of 6 temperature and 9 moisture levels on survival of *Verticillium albo-atrum* microsclerotia was tested in a nonsterile Chehalis sandy loam. Screened air-dried soil was artificially infested with microsclerotia obtained by growing *Verticillium* on cellophane placed over potato-dextrose agar. Soil was adjusted to air-dry, 25, 50, 75, and 100% moisture holding capacity and flooded moisture levels. Soil temperatures of 5°, 10°, 15°, 20°, 25°, 30°, and 40°C were maintained in soil temperature tanks and constant-temperature cabinets. The population of viable *Verticillium* units was determined at regular intervals for 6 months by soil dilutions employing an alcohol agar medium; then test plants were grown in the remaining soil. In general, microsclerotia survived poorly in soils held above 25°C. Flooding soils rapidly reduced the microsclerotial population at all temperature levels. The surviving population decreased rapidly as temperature increased from 25° to 40°C. Survival was best in soils held between 5° to 15°C and at 50 to 75% moisture holding capacity. Microsclerotia survived temperatures of 30°C from 12 days to 6 months, and 40°C from 3 to 35 days, depending on the moisture content of the soil.

Mechanical transmission of two strains of sweet cherry rugose mosaic, mild rusty mottle, and rasp leaf viruses.—*George Nyland.*—Mechanical transmission of virus was obtained from different trees of sweet cherry infected with 2 strains of cherry rugose mosaic, mild rusty mottle, and rasp leaf viruses. One strain of rugose mosaic virus was successfully transferred back to cherry with production of typical symptoms. With the 2 strains of cherry rugose mosaic virus, juice transmission was accomplished from both *Prunus avium* and *P. mahaleb*, and with 1 strain also from *P. persicae*. Symptoms with the rugose mosaic isolates were produced on *Chenopodium amaranticolor*, Petunia, Gomphrena, and Zinnia. In *C. amaranticolor*, chlorotic and necrotic local lesions were followed by systemic symptoms in the form of blotches, rings, vein banding, and severe leaf distortion. Petunia leaves showed vein clearing and, later, dark- and light-green mosaic. In Gomphrena, severe chlorosis and deformity of young leaves occurred along with yellow chlorotic rings, line patterns, and mottle. The viruses obtained from trees infected with mild rusty mottle and cherry rasp leaf were detected only in *C. amaranticolor* and only systemic symptoms were observed. Neither of these viruses has yet been returned to cherry. No reaction between antisera of Arabis mosaic and raspberry ringspot viruses obtained from England and the 2 strains of rugose mosaic and mild rusty mottle viruses could be detected with the agar diffusion method. Results

were inconclusive when the virus from the cherry rasp leaf tree was tested against these antisera.

Gilbertella fruit rot of peaches in California.—*Joseph M. Ogawa, E. E. Butler and Stuart D. Lyda.*—*Gilbertella persicaria* is reported for the first time from California. The pathogen is widespread and causes a disease of economic importance on peaches during storage. It also causes rot of ripe peach fruit in the field, but the importance of field losses has not been evaluated. At low relative humidity, disease symptoms on peach fruit are similar to symptoms caused by *Rhizopus stolonifer*. The optimum temperature for conidial germination, mycelial growth, and fruit rot is 30–33°C. Sporangiospores of *G. persicaria* are transmitted from diseased to healthy peach fruit by *Drosophila melanogaster* and *Carpophilus hemipterus*.

The effect of gibberellic acid on the parasitism of Rhizoctonia solani on beans and cotton.—*Lawrence J. Petersen, James E. DeVay, and Byron R. Houston.*—Disease development in Red Kidney bean and Acala cotton was greater in plants grown in soil infested with California isolate Rh-5 of *Rhizoctonia solani* and treated with a foliar spray containing 50 ppm of potassium gibberellate (g.a.) than in plants not treated with g.a. Rh-5 was isolated from a black scurf sclerotium on White Rose potatoes. In artificial media this isolate showed an increased growth response to 10 ppm of g.a., whereas 3 other pathogenic isolates of *R. solani* did not respond to g.a. Moreover, disease development in beans caused by these other isolates was not affected by foliar sprays of g.a. Studies on the translocation of radioactive g.a. in beans from leaves to roots and root medium indicated that little if any g.a. was excreted by the roots. Thus, it is doubtful that g.a. acted directly as a specific stimulant on isolate Rh-5 in prepenetration stages. Comparative disease indices showed that untreated beans had a mean disease index of 0.48 whereas treated plants had a mean disease index of 1.48. Greater numbers of treated plants were recorded in the higher infection classes, whereas the reverse was true with untreated plants.

Increased production of geminate buds on peach-mosaic-infected peach trees.—*T. S. Pine.*—Geminate buds are two complete flower buds on a common receptacle but enclosed by a single set of bud scales. Single and geminate buds appear identical on the dormant tree. Geminate buds occur naturally in small numbers on healthy peach trees. They are formed at random on healthy and diseased trees and may be found singly at a node with a leaf bud or as part of a pair of flower buds at a node. Counts of dormant flower buds in the laboratory and of buds in the field at budswell showed that the numbers of geminate buds formed were significantly greater on peach trees infected with the peach mosaic virus than on healthy trees. Of 1489 healthy flower buds counted during the winter and early spring of 1960, only 103 (6.9%) were geminate; of 1159 flower buds from diseased trees counted during the same period, 339 (29.3%) were geminate. Flowers and fruits from geminate buds were not noticeably aborted. Increased production of geminate buds is considered to be a virus-induced physiological response of the host.

Flowering crab apple varieties as quick indicator hosts for latent apple viruses.—*J. E. Reynolds and J. A. Milbrath.*—A sudden freeze in November, 1955, killed many dormant apple buds in western Oregon. Nurserymen regrafted many of these trees in the spring of 1956. One nurseryman noted that Hopa crab following Yellow Transparent apples was dwarfed and mottled. In greenhouse trials Hopa scions were grafted on top of apple seedlings, and buds from the diseased Hopa crab or buds from 9 normal appearing apple varieties were inserted below the grafts. Soon after the Hopa crab produced new growth, red mottled and distorted leaves developed. Different trees gave different degrees of severity of symptoms indicating various strains of virus. An experiment was repeated, and 88 varieties of flowering crab were inoculated with one source of virus. Five varieties gave a severe reaction, 6 produced moderate virus symptoms and 77 remained symptomless after several inches of growth. Certain varieties of flowering crab appear to be useful in rapid-indexing techniques for latent apple viruses.

Factors determining the rate of bean yellow mosaic virus transmission by the aphid Myzus persicae.—*K. G. Swenson and S. S. Sohi.*—The rate of BYMV transmission was reduced when the virus culture was maintained by mechanical transfer as compared to maintenance by aphid transfer. Broad bean plants treated in a uniform manner and inoculated from the same inoculum source sometimes showed great individual variation as virus sources for aphids. Susceptibility of bean plants to aphid inoculation was altered by changes in the nutritional level of the beans. Bean susceptibility increased with decreasing temperature in the range of 18–27°C. Aphids from vigorously growing young *Brassica pekinensis* leaves transmitted at a higher rate than aphids from old crowded colonies. Aphids from young leaves of *B. pekinensis* transmitted at a higher rate than aphids from mature leaves of the same plants. Virus-transmitting ability may vary with aphids from different leaves of the same plant or from different plants. This appeared to be the greatest source of variation within experiments.

Pathogenicity of Monosporic *versus* polysporic cultures of *Urocystis colchici*.—*H. Tachibana and R. Duran.*—Monosporic and polysporic cultures of *Urocystis colchici* (*U. cepulae*) employed in pathogenicity studies on onion toward possible elucidation of sexual phenomena of this fungus gave definite evidence of heterothallism in this species. Six different polysporic cultures, each started from 12 or more teliospores, were all pathogenic, whereas 95 of 100 monoteliosporic cultures produced no infection. Infection that was produced by monosporic cultures was probably due to experimental error. When one of the nonpathogenic monosporic cultures was paired with 10 other nonpathogenic monosporic cultures, 6 of the 10 paired combinations were pathogenic. Hypothesizing pathogenic combinations to consist of plus and minus compatible lines, these 10 monosporic lines were paired in all possible combinations and tested for pathogenicity and the hypothesis. Smut was produced only by combinations between plus and minus monosporic lines; thus the hypothesis was confirmed.

The influence of *Tylenchulus semipenetrans* on growth of grape cuttings.—*S. D. Van Gundy.*—Many of the grape vineyards in the San Joaquin Valley of Central California are infested with the citrus nematode. Rooted tip-cuttings of Thompson seedless grape (*Vitus vinifera*) planted in 1-gal. crocks were infested with 280,000 citrus nematode larvae per crock. The nematodes were collected from infested citrus roots and treated with 1:1000 copper sulfate solution for 15 minutes. The uninoculated and inoculated seedlings were replicated 7 times. The plants were grown for 1 year, during which the tops were harvested 4 times. The average reduction in dry weights of the tops was 33% (12%–48%), and of the roots was 16% (0–42%) over uninfested. Examinations of the roots showed that a high rate of reproduction and reinfection had occurred on the new roots. The citrus nematode population averaged between 4 and 5 million per pot at the end of the experiment.

Transmissible decline diseases of apple.—*Maurice F. Welsh and F. W. L. Keane.*—Investigations of viruses in apple in British Columbia have demonstrated that several forms of apple tree decline are graft-transmissible, and that at least 5 diseases with different etiology are involved. These are stem pitting, causing reduced vigor in a number of crabapple and apple varieties; delayed dormancy and dieback of Spartan; decline of Spy 227; reduced scion take and weak development of a number of crabapple varieties, and of the Russian apple seedling R12740-7A;

and a progressive weakening of Virginia crab that culminates in death of trees. A graft-transmissible decline affects Hyslop crab, but, so far, evidence is lacking to indicate whether it is caused by a distinct virus. Chlorotic leaf spot virus appears to be responsible for the reduced scion take and weak growth of seedling R12740-7A, but the identity of the virus causing similar symptoms in crabapple varieties has not been established.

An analysis of a new phenomenon of TMV abortive infections.—*Jia-Hsi Wu and Irving Rappaport.*—Whereas inoculation of pinto bean leaves with TMV strain U1 results in the formation of characteristic local lesions, similar inoculation with the related mild strain U2 does not. No apparent or measurable infection is produced from U2 inoculation. Nevertheless, in a mixed inoculum containing both strains, interference with U1 lesion formation is encountered. The number of U1 lesions appearing is reduced, suggesting an active competition between the two virus strains for potentially infectious sites. More detailed studies on the nature of this competition were conducted by irradiating leaves of pinto beans with ultraviolet light following infection with a mixed inoculum. The data suggest that those sites containing a U1 and one or more U2 particles are either incapable of initiating an infection or abort before producing any demonstrable effect. As a consequence of UV irradiation, however, a fraction of these mixed sites go on to produce local lesions. This fraction is directly proportional to the probability of killing the one or more U2 particles in the mixed site while at the same time not injuring the U1 particle. Thus, by irradiating leaves previously inoculated with a mixture of U1 and U2 viruses, a fraction of the abortive infections can be resuscitated.

PHYTOPATHOLOGICAL NOTES

TRANSMISSION OF THE RINGSPOT VIRUS OF STONE FRUITS FROM SQUASH TO SQUASH BY FOLIAGE CONTACT

K. G. Swenson and G. P. Carpenter

Reported herein is transmission of the stone fruit ringspot virus by foliage contact from diseased to healthy squash. The same virus strain was previously used in experiments on natural spread of ringspot virus in squash plots (4). It produces conspicuous and extensive chlorosis in Buttercup squash, *Cucurbita maxima* Duchesne (3), the variety used in all these experiments.

Sixteen of 33 healthy plants were infected when leafhoppers were introduced into cages containing diseased and healthy squash plants. Infected plants resulted in cages with each of three leafhopper species (*Draeculacephala crassicornis* Van D., *Euscelidius variegatus* (Kbm.), and *Macrosteles fascifrons* Stål). Considerable contact between the diseased and healthy squash plants in the cages indicated that virus transfer might have been by contact. Diseased and healthy plants were again placed in the cages, but no leafhoppers included. Fourteen of 43 plants were infected. No transmission occurred in tests with leafhoppers in the cages when contact between diseased and healthy plants was prevented.

Mechanical transfer by foliage contact in the cages could have been a reflection of special environmental conditions, e.g., humidity higher than usual. This was tested in a greenhouse experiment in which the plants were not placed in cages. In the first of three treatments, healthy squash plants growing in separate containers were each trained up the same stake as a diseased plant. In the second treatment, a diseased plant and a healthy plant were grown in the same container, allowing extensive root contact. The two plants were trained up separate stakes so that no foliage contact occurred. These diseased plants in treatments 1 and 2 were inoculated mechanically. In a third treatment, 5 cc of inoculum was poured on the soil of each container. This was to check against the possibility that infections in the first two treatments resulted from inoculum washed off the plants after mechanical inoculation. A group of uninoculated plants was included as checks. There were 6 replicates. In each replicate, treatments 1 and 2 were each represented by eight pairs of plants; treatment 3 and the check were each represented by eight plants in individual containers.

Twelve of the 48 uninoculated plants were infected with ringspot virus in the first treatment (foliage contact with diseased plants). No transmission resulted in the other two treatments, and the checks remained virus-free. Uninfected plants were discarded after 3 months.

Discussion.—The readiness of transfer of the stone fruit ringspot virus by foliage contact was unexpected Consistent and efficient transfer by mechanical inoculation requires considerable care. The yield of this virus from diseased cucurbits is low (2) compared to that of tobacco mosaic virus and potato virus X (1), which are easily transmitted by foliage contact (1) and, of course, by mechanical inoculation.

Milbrath and Swenson (4) stated that, in natural spread of the stone fruit ringspot virus in squash plots, probability of infection decreased with increasing distance from the diseased plants. Transmission by foliage contact would account for the majority of naturally infected plants in these plots, although healthy plants that had no contact with diseased plants did become infected.—Department of Entomology, Oregon State College and Entomology Research Division, ARS, U.S.D.A.

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SPREAD OF PETAL BLIGHT OF CAMELLIAS BY AIR-BORNE ASCOSPORES OF SCLEROTINIA CAMELLIAE

Natale Zummo and A. G. Plakidas

Respectively Research Assistant and Professor of Plant Pathology.

It has been shown by several workers (1, 2, 3) that many fungicidal chemicals such as sulphur, ferbam (ferric dimethyldithiocarbamate), captan (*N*-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide), Krenite-26 (19% sodium4,6-dinitro-*o*-cresoxide + 5% sodium butyl naphthalene sulfonate + 2% sodium chromate), and Terraclor (pentachloronitrobenzene 75% wettable powder), applied to the soil or mulch, inhibited the formation of apothecia of the camellia petal blight fungus, *Sclerotinia camelliae* Hara. Terraclor, in particular, at 150 lb/A. or higher, completely suppressed normal apothecial formation under Louisiana conditions (1, and unpublished data by the writers).

This fungus has no conidial stage, ascospores are the sole source of inoculum, and there is no secondary spread of infection from flower to flower. Theoretically, therefore, ground sprays with a fungicide, such as Terraclor, that completely inhibits the formation of apothecia and ascospores should control the blight. In actual practice, however, control is not satisfactory. Wind-borne ascospores from unsprayed properties adjacent or close to the sprayed property were assumed to be the inoculum in such cases. No data were available regarding the distances that viable ascospores could be carried by the wind, and there was no easy method for obtaining such data. Setting spore traps presented difficulties. The ascospores of this fungus are not particularly distinctive and therefore cannot be identified with certainty on the slides. Furthermore, even if the spores trapped on slides were recognizable, it would not be certain that they were viable and capable of causing infection. The use of live traps, potted camellia plants with open blossoms set at different distances from an infested property, was thought of, but even that method was infeasible until recently because the known blight-infested properties in Louisiana were in urban areas, with thousands of gardens and no isolation. During the 1960 blooming season, an isolated infested property was located near Hammond, Louisiana. This property (20 acres and containing about 1500 camellias) was at least 3 miles from any other property with camellias.

Potted camellia plants, with an average of 6 flower buds per plant, were set out, in groups of 3 per location, at intervals of 1/20 of a mile for the first ¼ mile and then at intervals of 1/10 of a mile up to 7/10 of a mile. No infection occurred on the plants at 0.5 The setup was replicated along two roads, one running west and the other north of the property. In the series of plants along the west road, blight developed on some of the flowers in all locations from .05 to 0.4 of a mile. No infection occurred on the plants at 0.5 of a mile; the plants at 0.6 and 0.7 mile were lost (stolen) and no information was obtained from them. In the north road replication, infection occurred on some of the flowers of the plants in every location except at 0.5 and 0.6 mile. Thus, the maximum distance that viable ascospores can be carried by the wind was not determined. This would naturally vary with locality, and would be influenced by such factors as direction and velocity of prevailing winds, and temperature and humidity. In this particular case, the air-borne spore load must have been very heavy because the incidence of blight was relatively high in some groups (respectively 37% and 63% at 0.3 mile on the west and north road replications).—Department of Botany, Louisiana State University, Baton Rouge.

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DETECTION OF HAIRY ROOT PATHOGEN, AGROBACTERIUM RHIZOGENES, BY THE USE OF FLESHY ROOTS

Peter A. Ark and James P. Thompson

The pathogen of the hairy root disease, *Agrobacterium rhizogenes* (Riker et al) Conn, grows well on most laborataory media and presents no particular difficulty in its recovery from diseased material. Fulfillment of the fourth Koch postulate, however, as well as virulence tests with laboratory cultures of *A. rhizogenes*, has been considered a difficult procedure on account of the slow development of *A. rhizogenes* on such standard test plants as *Kalanchoë daigremontiana* Hamet & Perrier, or *Sedum spectabile* Bor. This paper presents a method that is satisfactory for initial recovery of the pathogen from diseased plants as well as for prompt identification of isolates of *A. rhizogenes*.

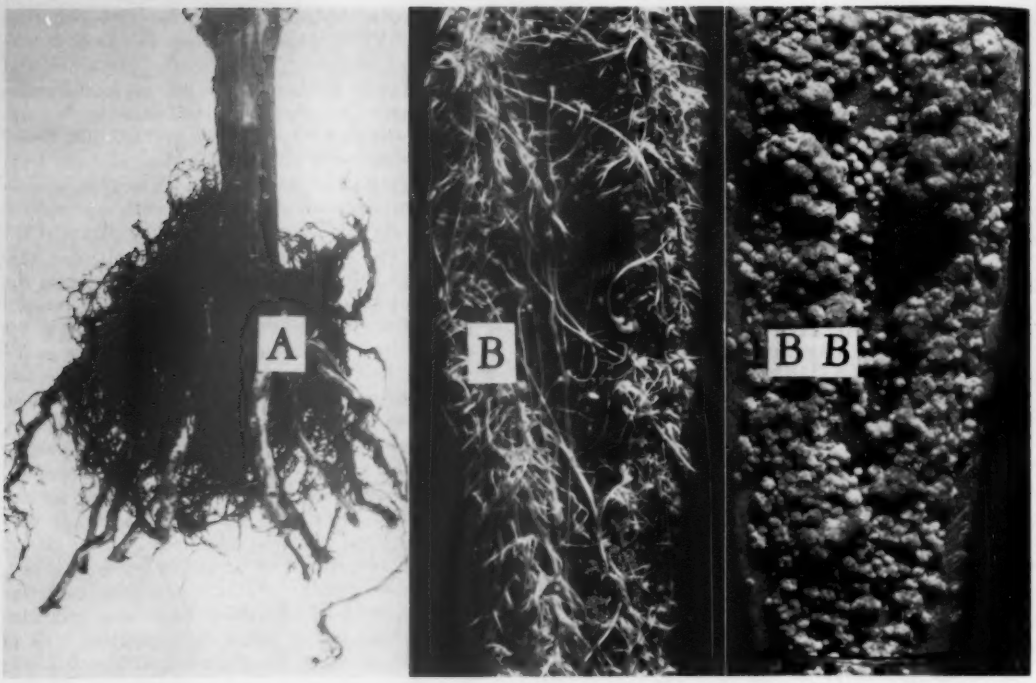

Fig. 1.—**A)** Hairy root disease of *Rosa multiflora* rootstock. Natural infection. **B)** Hairy root symptoms on sliced carrot root, produced by swabbing the cut surface with a suspension of ground-up roots from A in distilled water. **BB)** Crown gall on sliced carrot root produced by smearing the cut surface with a pure culture of *Agrobacterium tumefaciens*.

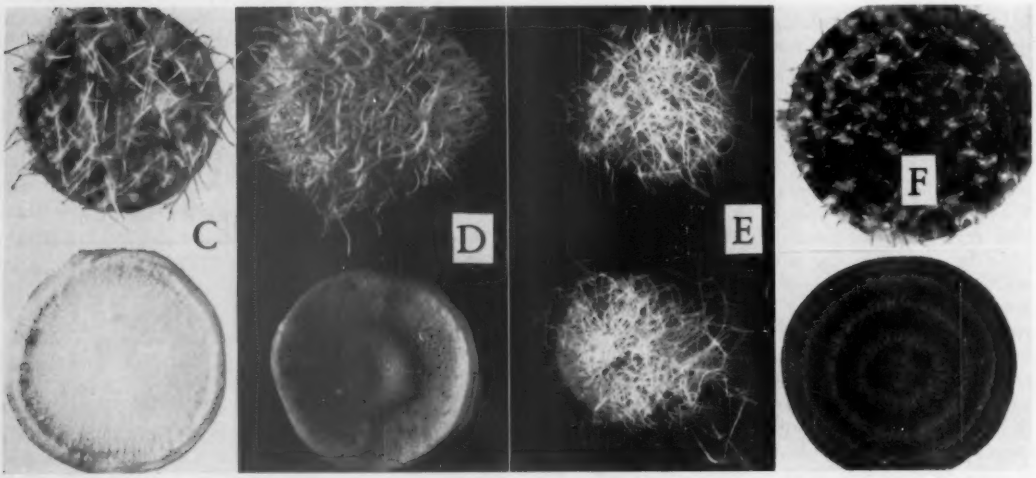

Fig. 2.—Development of hairy root disease from pure cultures of *Agrobacterium rhizogenes* isolated from rose or, as in E, obtained from the American Culture Collection. Discs showing no roots are the checks, which were swabbed with sterile distilled water. **C)** turnip; **D)** parsnip; **E)** carrot; **F)** table beet.

For use in this work, samples of *Rosa multiflora* rootstocks (Fig. 1-A) were obtained from one locality, and Ragged Robin rose from another. Pure cultures of *A. rhizogenes* were made from field and experimentally infected material by plating diseased parts on potato-dextrose-peptone agar (pH 7.2) and incubating at 28°C. The isolates were grown on slants of potato-dextrose-peptone agar.

As substrates for the hairy root test the following fleshy roots were used: carrot (var. Chantenay), turnip (var. Purple top), table beet, parsnip, and Jerusalem artichoke. The roots were washed in water plus some suitable detergent to free them of dirt. After being rinsed in several changes of distilled water the roots were dried on paper towels. The use of mercurial disinfectants was avoided because of their retention by plant tissues and their unfavorable effect on the test organisms. The roots were then sliced longitudinally or cut into discs with a sterile knife and placed in deep Petri dishes. Inoculum was prepared either by grinding diseased parts of the infected plants in sterile distilled water or suspending agar growth in distilled water. The freshly cut surfaces of the experimental roots were cotton-swabbed with appropriate inocula, and the Petri dishes were incubated at room temperature.

A profusion of roots developed on the inoculated root surfaces on all species used in the experiments. In the experiments where the samples were taken from mixed infections of hairy root and crown gall, symptoms of both diseases appeared on the test pieces. By culturing the two types of lesions separately, it was possible to isolate pure cultures of *A. rhizogenes* and *Agrobacterium tumefaciens* (E. F. Sm. & Towns) Conn, which when used to inoculate freshly cut surfaces of the test roots produced either typical hairy root (Fig. 2) or crown gall (Fig. 1-BB).

The hairy root symptoms develop faster on turnip and table beet slices (Fig. 2-C,F) than on carrot, parsnip, or Jerusalem artichoke. The small roots produced, however, are coarser and longer on carrot and parsnip (Fig. 2-D,E) tissues than on the other hosts used. The development of hairy root on turnip root discs can be seen as early as 7 days after inoculation, on carrot in 12–14 days. The table beet showed more numerous infections and shorter hairs (Fig. 2-F) than the turnip or carrot.

An old culture of *A. rhizogenes* from apple hairy root made in about 1942, obtained from the American Type Culture Collection (No. 11325), was found to be virulent (Fig. 2-E) when tested as outlined above.

The tendency of certain fleshy roots to produce hairy root symptoms on freshly cut surfaces inoculated with *A. rhizogenes* affords a rapid means of detecting the presence of this organism in soil or plant tissue. For this purpose a suspension of the soil or ground-up plant tissues (Fig. 1-B) is smeared on freshly cut surfaces of carrot, turnip, or beet, and incubated at 25°C.—Department of Plant Pathology, University of California, Berkeley.

POSSIBLE IDENTITY OF A FUNGITOXIC COMPOUND FROM CARROT ROOTS

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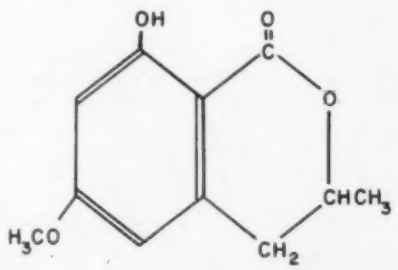
Condon and Kuc (2) reported the isolation of a fungitoxic compound from carrots inoculated with *Ceratocystis fimbriata* (Ell. & Halst.) J. A. Elliott. The compound was not present in the uninoculated carrots and the authors suggested that production of the toxic substance was the result of interaction between the living host and the fungus. The compound isolated by Condon and Kuc was only partially characterized by them, and no specific structure assignment was made.

We would like to draw attention to the very close similarity between the properties of the compound isolated by Condon and Kuc and 3-methyl-6-methoxy-8-hydroxy-3,4-dihydroisocoumarin (I), a substance obtained from carrots held in cold storage (4). As shown in Table 1, the melting points, optical rotations, absorption peaks, analyses and ferric chloride reactions of the two preparations agree very closely. Condon and Kuc also cite evidence for the presence in their compound of an ester group, a C-Me group, and a hydrogen-bonded C=O. All of these substituents are present in I. In fact, the failure of Condon and Kuc to detect alkoxy groups is the only finding not reconcilable with the assignment of structure I to their compound.

3-methyl-6-methoxy-8-hydroxy-3,4-dihydroisocoumarin could not be detected in freshly harvested carrots (4). It was found most frequently in roots held 4–8 weeks at 32°F, and accumulated in greatest amount in the phloem (3). The formation of this compound was accompanied, by other chemical changes in the carrots, most notably the formation of bitter, steam-volatile



I

STRUCTURE OF 3-METHYL-6-METHOXY-8-HYDROXY-3,4-DIHYDROISOCOUMARIN

oils (3). Although there were no obvious signs of mold infections, this possibility cannot be discounted. On the other hand, Condon and Kuc have not shown that their fungitoxic compound cannot be produced in the absence of *Ceratocystis fimbriata* under physiologically abnormal conditions, such as cold storage. It is conceivable that an attacking organism might produce a set of conditions that initiate a syndrome comparable to one caused by an abnormal physiological environment. In this connection it may be of interest that ethylene has been implicated in the formation of compound I during storage of carrot roots (1).

LITERATURE CITED

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3. Sondheimer, E. 1957. Bitter flavor in carrots. III. The isolation of a compound with spectral characteristics similar to hydrocarbon extracts of bitter carrots. Food Research 22:296-299.
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Table 1.—Comparison of the properties and analytical data of the fungitoxic compound isolated by Condon and Kuć and 3-methyl-6-methoxy-8-hydroxy-3,4-dihydroisocoumarin.

	Condon and Kuc's Compound	3-methyl-6-methoxy-8-hydroxy-3,4-dihydroisocoumarin
Melting point	75.7°	75–76°
Optical rotation	$[\alpha]_D^{25}$ –51.8°	$[\alpha]_D^{24}$ –56° (in methanol)
Absorption peaks	267mμ ε11390 301mμ ε4550 5.99μ	267mμ ε14800 302mμ ε6000 6.02μ (KBr pellet)
Ferric chloride	purple	violet
Analyses	C 63.4 H 5.86 O 30.75	C 63.45 H 5.81 O 30.7

THE PRESIDENT'S COLUMN

Of all Society activities, the Annual Meeting is of prime concern to the members and of comparable importance to our Journal, PHYTOPATHOLOGY. The question of planning the meeting poses various problems which admittedly cannot be solved to the satisfaction of everyone for every meeting. However, we think that the meetings can be planned in such a way that they will be generally satisfactory and follow a more or less logical course. There are two main considerations: the time and place, and the internal planning or organization of the meeting.

Let us first consider the time and place. For the first 33 years, we, in common with many scientific societies, accepted the logical status quo and unquestionably met with the American Association for the Advancement of Science during Christmas week. With the advent of World War II, interrupted schedules and transportation difficulties, we began to meet independently, alone or with the Potato Association of America or Entomological Society of America. In 1952 we held our first meeting with the American Institute of Biological Sciences which we had joined a few years previously. Thus, there was initiated a new scheme of meetings. Since 1943, nine meetings have been held with the PAA, ESA, or alone, five in conjunction with the AIBS and five with the AAAS. The sequence, following no particular pattern, has been decided by the Council on the basis of past meetings, future plans of the AIBS and AAAS, and invitations from local plant pathological groups. However, there has been only one meeting with the AAAS during the past 13 years. The independent meetings have been mostly in Cincinnati or Columbus and twice in "resort" areas, i.e., Estes Park, Colo., and Green Lake, Wis.

It is our impression that as a group the teachers and graduate students prefer meetings in the late summer or Christmas week, while others with a less restricted schedule do not favor Christmas week. The meetings on university campuses, i.e., with the AIBS, are most popular with those on limited or no expense accounts. Members with the broadest interests encompassing sister sciences favor meetings with the AIBS or AAAS. Without a doubt, the Estes Park and Green Lake meetings have provoked the most extreme expressions of opinion. The perhaps less staid members who enjoy camping with their families and who do not mind the somewhat less than deluxe accommodations are enthusiastic in their endorsement. On the other hand, some members traveling alone, and certainly those without their cars, are notably devoid of enthusiasm.

By an analysis of our membership it would be possible to allocate our meetings in proportion to the classification of the members as is done in a Gallup Poll sampling. However, we doubt if this is necessary. We would suggest as a rule of thumb that two meetings out of three be held in conjunction with the AIBS or AAAS and that a "resort" meeting be held not oftener than once in 6 years or perhaps longer.

The internal planning of the meetings is now in the hands of a new Program Committee. A few years ago the then President George W. Fischer conducted an extensive poll to ascertain the member preferences. The main problem is accommodating an increasing number of contributed papers, now over 200. All are agreed that the poorer papers should be eliminated, but no one knows just how to do this effectively, at least from an abstract. We endorse the new emphasis on symposia, but we do not think that there should be an undue restriction of contributed papers. After all, according to the Fischer poll, contributed papers are the main reason for attending meetings.

How have the large scientific societies handled this question? The American Chemical Society, for example, is 40 times larger than ours. It has over 20 semi-autonomous subject matter sections, and meets in some dozen hotels in a given city for 5 days. The largest sections hold up to 4 concurrent sessions. Thus, at a given time the ACS may hold some 30 concurrent sessions.

We believe that the immediate answer to the increasing number of contributed papers is more concurrent sessions and a maximum time limit of 10 minutes. Let us not try to limit the growth of our Society by curtailing contributed papers to the level of earlier days. Instead let us rejoice in our growth recognizing that we must adapt our program to accommodate this increase in contributed papers.

S. E. A. McC.

NEWS

Editor: K. W. KREITLOW, Plant Industry Station, Beltsville, Md.

The Northeastern Division held its 20th Annual Meeting on November 3 and 4 in West Springfield, Massachusetts. There were 200 in attendance and 34 papers were presented. The following officers were elected for the coming year: President, D. H. Marsden; Vice President, R. H. Daines; Secretary-Treasurer, W. F. Mai; and Councilor, G. A. Brandes. A committee was appointed to formulate rules to govern the recognition of outstanding contributions to the science of Plant Pathology. Dr. J. S. Boyce, guest speaker, discussed experiences gained during his long service in Forest Pathology.

Pathologist James W. Lorbeer, a recent recipient of the Ph.D. degree at the University of California, Berkeley, was appointed Assistant Professor of plant pathology at Cornell University, December 15. Dr. Lorbeer's responsibilities will consist of research on diseases of vegetables with special emphasis on muckland crops.

The Potomac Division will hold its 18th annual meeting March 2 and 3 in the auditorium at the Plant Industry Station, Beltsville, Maryland.

A Retired Professors' Registry was established November, 1957, by the Association of American Colleges and the American Association of University Professors under a grant from the Ford Foundation. The Registry serves primarily as a placement service for faculty members who want appointments in institutions other than those from which they have retired, but is also open to other retirees qualified for academic activities. The Registry operates without fees and supplies to colleges a coded list of registrants. Retirees and those about to retire are urged to register by writing to the office at 1785 Massachusetts Avenue, N.W., Washington 6, D. C.

The Gold Pecan Award of the National Pecan Shellers and Processors Association was presented to phytopathologist, John R. Cole, for inspiring leadership and untiring efforts in research and improved cultural practices, at the 53rd Annual Convention of the Southeastern Pecan Growers Association held in Natchez, Mississippi.

Crop Science, a new research journal, will appear in February 1961 as the official publication of the Crop Science Society of America, an affiliate of the American Society of Agronomy. This new bimonthly journal will carry research reports on breeding, genetics, physiology, ecology, and management of field crops, pastures, ranges, and turfgrasses from crop scientists in the U. S., Canada, and other countries. Crop Science will be a companion publication to Agronomy Journal. It will alternate in publication dates with the Journal and will carry the articles of direct interest to workers in the above-mentioned areas of research. Agronomy Journal will continue to carry the articles of wider agronomic scope—of interest to both crop and soil scientists, seed and weed technologists, plant pathologists, agricultural meteorologists, and others. Publication of research reports in Crop Science will be open to members of the Crop Science Society, with joint membership in the American Society of Agronomy. Detailed information on publication in or subscription to Crop Science or Agronomy Journal or both may be obtained from the American Society of Agronomy, 2702 Monroe Street, Madison 5, Wisconsin.

Research Assistant, Francis A. Wood, University of Minnesota, St. Paul, was awarded the Mycological Society Graduate Fellowship for 1960-61.

Plant pathologist M. F. Kernkamp, Assistant Director, Minnesota Agricultural Experiment Station was on leave from July 1 to November 1, studying research administration and plant pathology research in Europe.

Virologist Ellen M. Ball is the former Ellen L. Moorhead at the University of Nebraska. Dr. Moorhead was married October 7, 1960, to Entomologist Harold J. Ball, University of Nebraska. Dr. Ellen Ball will continue her studies on serology of cereal viruses.

Research fellow of the University of Minnesota, Kenneth Knutson, has accepted a position at the Agricultural Experiment Station in Moscow, Idaho, to conduct research on potatoes and cereals.

Phytopathologist Cedric W. Kuhn was recently appointed Assistant Plant Pathologist at the Georgia Experiment Station, Experiment. Dr. Kuhn is a graduate of Purdue University and will conduct research on plant viruses.

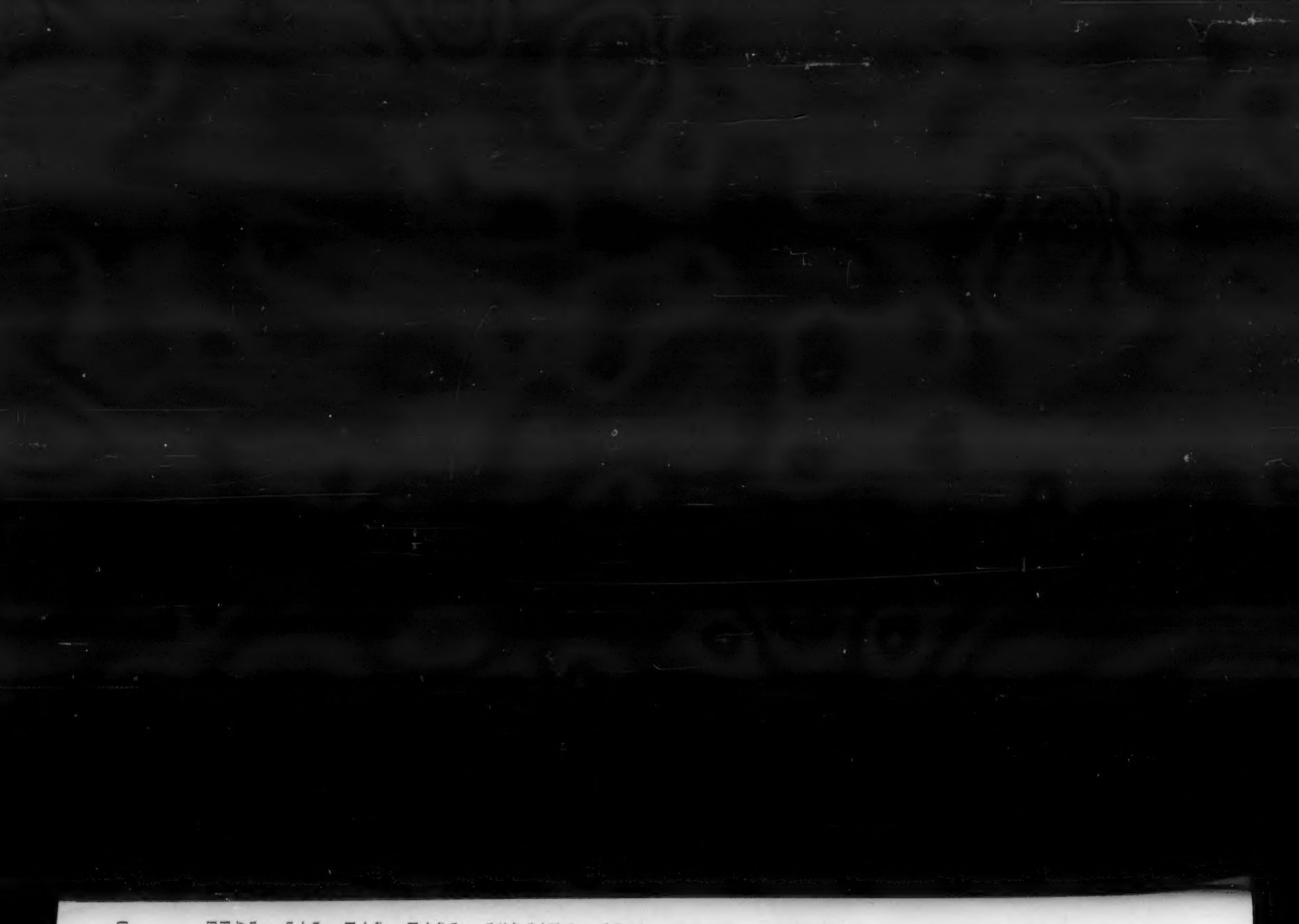
Plant pathologist Richard T. Hanlin has recently accepted an appointment as plant pathologist at the Georgia Experiment Station, Experiment, to conduct research on the morphology and taxonomy of Ascomycetes. Dr. Hanlin received his Ph.D. from the University of Michigan.

Assistant plant pathologist Norman C. Schenck, Florida Agricultural Experiment Station, Leesburg, spent a 10-week period of his sabbatical leave, September 15 to November 1, at the Department of Plant Pathology, North Carolina State College, Raleigh. Dr. Schenck investigated the ecology of soil-borne plant pathogens involving fungi and nematodes in collaboration with Drs. E. A. Curl and E. J. Cairns.

Plant pathologist, Vernyl D. Pederson has accepted a position as Assistant Professor of Plant Pathology at South Dakota State College, Brookings, where he is engaged in research on barley and oat diseases. Dr. Pederson recently obtained his Ph.D. degree from Iowa State University.

Phytopathologist R. T. Gudauskas was recently appointed Assistant Plant Pathologist in the Department of Botany and Plant Pathology, Alabama Polytechnic Institute, Auburn. Dr. Gudauskas will work on grass diseases. He recently received his Ph.D. degree from the University of Illinois, Urbana.

Pathologist Richard D. Schein, Pennsylvania State University, University Park, attended the Second International Congress of Bioclimatology and Biometeorology in London from September 4 to 10 as the official representative of the Society. Dr. Schein also visited research institutes in England, Belgium and the Netherlands. His primary interest was in observing controlled-environment rooms and greenhouses to obtain ideas for phytopathological applications of the growth-chambers at Penn. State.

Deaths—George E. Thompson, Department of Plant Pathology and Plant Breeding, University of Georgia died suddenly November 23 from a heart attack. Dr. Thompson had been at the University for 23 years and was known for his teaching and research on forest tree diseases.

Prof. Dr. T. H. Thung, Director, Laboratory of Virology, Agricultural University, Wageningen, died suddenly November 18, at the age of 63. Dr. Thung had worked for many years as plant pathologist in Java. He was Head of the Virology Department of the Institute of Phytopathological Research at Wageningen, the Netherlands from 1949-1957, and at the same time Associate Professor in Virology at the University. From 1957 until his death he had a full-time position as Ordinary Professor to the Wageningen University. Dr. Thung was well known for his work on tobacco and potato virus diseases. He was one of the first to recognize the possibilities of immunizing plants against a certain virus by inoculating such plants with another less virulent strain of the virus. Dr. Thung organized the first three International Conferences on potato virus diseases.